The Economic and Greenhouse Gas Emission Impacts of Electric Energy Efficiency Investments:

A Wisconsin Case Study

Rebuild America Guide Series

U.S. Department of Energy

Rebuild America

Rebuild America is a network of community partnerships - made up of local governments and businesses - that save money by saving energy. These voluntary partnerships, working with the U.S. Department of Energy, choose the best ways to improve the energy efficiency of commercial, government and apartment buildings. Rebuild America supports them with business and technical tools and customized assistance.

By the year 2003, 250 Rebuild America partnerships will be involved in over 2 billion square feet of building renovations, which will save $650 million every year in energy costs, generate $3 billion in private community investment, create 26,000 new jobs, and reduce air pollution by 1.6 million tons of carbon dioxide a year.

Acknowledgments

The Rebuild America program would like to acknowledge the team of dedicated individuals who wrote and produced this case study. We thank them for their time, effort, expertise, and personal commitment.

The principal authors of this case study were Steve Clemmer, Stephen Olson, and Michael Arny. Michael Arny also served as the project manger. This report was prepared for the Rebuild America program by the Consortium for Integrated Resource Planning in the Engineering Professional Development Department at the University of Wisconsin in cooperation with the Wisconsin Department of Natural Resources, and Leonardo Academy.

FOREWORD

The Purpose of This Report

This report was prepared to provide state energy and environmental policy makers and legislators with information on the state-level jobs and economic activity benefits of taking action to increase the delivery of energy efficiency. It provides a state-level case study showing the benefits of increased delivery of energy efficiency, including increased employment and increased disposable income. This case study was prepared for a specific state, Wisconsin, so that the analysis could be specific and concrete. This information should be helpful to state-level policy makers and legislators considering measures to increase the delivery of energy efficiency in their states as well as those considering how to reduce the emissions of greenhouse gases and other pollutants.

There are, of course many things that states can do to increase the delivery of energy efficiency. Within the context of the U.S. Department of Energy (DOE) Rebuild America Program several examples are

— encourage communities within the state to form Rebuild America Partnerships,

— implementing comprehensive performance contracting enabling legislation so that all state and local government organizations have access to using energy service companies (ESCOs) to acquire energy efficiency improvements and facility upgrades,

— support the inclusion of energy efficiency-based emission reductions in trading systems set up for reducing various environmental emissions. This will allow all organizations that install energy efficiency improvements in their facilities to receive the economic value of the emission reductions that their energy efficiency actions produce. This will make available an additional source of value that can be used to pay for the installed energy efficiency.

— actively participate in other efficiency-related activities such as the various Energy Star Programs.

This report is part of continuing financing services provided through DOE's Rebuild America Financial Services Program. Rebuild America Financial Services is part of the DOE Rebuild America Program.

FOREWORD

What is Rebuild America

The U.S. Department of Energy's Rebuild America Program is a network of community partnerships—made up of local governments, schools, universities, housing agencies and private businesses—that save money by saving energy. These voluntary partnerships, working with support provided through the Department, choose the best ways to plan and implement energy efficiency projects in the commercial, institutional, and multifamily residential buildings controlled by their partners.

Partnerships have access to products, services and peer experiences on buildings, energy, finance and more. With support provided nationally and led by regional teams, a program representative is assigned to each partnership to help in identifying local resources, financing options, and accessing special services from Rebuild America to aid in completing retrofits.

By the year 2003, 250 Rebuild America partnerships will be involved in over 2 billion square feet of building renovations, which will:

- save $650 million every year in energy costs
- generate $3 billion in private community investment
- create over 26,000 new jobs
- reduce air pollution by 1.6 million tons of carbon dioxide a year.

Rebuild America Financial Services

Rebuild America Financial Services, formerly DOE's "Energy Fitness" Program, is designed to aid local partnerships in developing, financing and implementing energy efficiency projects. It expands the earlier "Energy Fitness" Program from a focus on performance contracting to a broader scope that encompasses the full spectrum of financing options (internal capital or operating funds, debt instruments, lease or lease-purchase arrangements) for projects implemented with conventional or performance contracting.

It guides the choice of options best suited for a particular customer, and shows how government or utility incentives can improve the attractiveness of a financing package. Finally, it retains its earlier emphasis on the wise use of energy performance contracting as an implementation strategy that can be carried out with capital provided by one or a combination of the primary financing options mentioned (in parenthesis) above.

In addition to its guidance on the selection of financing options, Rebuild America Financial Services is also involved in activities that broaden the financing options in the various states, that strengthen market support for energy investments, and that aid

FOREWORD

access to capital.These activities include assisting states and provider partners in the development of model legislation necessary for state and local institutions to effectively use the performance contracting option, working with the National Association of Energy Service Companies for accreditation of ESCOs, and monitoring the impacts of utility restructuring on investment options. Rebuild America Financial Services aids access to capital by pointing partnerships toward programs offered by states, associations or private financing organizations that may be able to provide investment capital at the lowest possible rates.

Working with providers of financial services, customers of these services, and professional organizations Rebuild America Financial Services is designed to aid community partnerships in implementing successful financial strategies, understanding what financing alternatives are available, why a particular financing option should be selected, and how to derive maximum benefits from financing choices.

Products, Services, and Availability

Products and services consist of a range of written documents, workshops, and customized technical assistance. The core guide is "Financing Energy Efficiency in Buildings", a basic guide that provides definitions, descriptions, and advice for implementing successful financial strategies.The Guide is supplemented by items such as:

- case studies
- sample RFPs, RFQs, contract summaries
- materials describing the project development process and the relationship of financing to that process, and
- workshop materials

Workshops are designed in modules that cover basic financing alternatives, and more detailed training for each financing option, and for the integration of financing and implementation through conventional and performance contracting. Customized technical assistance is made available on a limited basis to address specific and major issues faced by partnerships.

Support from Rebuild America Financial Services is available primarily to organizations who are members of a Rebuild America community partnership or who are involved in the development or support of such partnerships. More information is available from the Rebuild America website at www.eren.doe.gov/buildings/rebuild/ or by calling your Rebuild America program representative. Direct web access to Rebuild America Financial Services is available at www.ornl.gov/rafs/.

FOREWORD

Rebuild America Financial Services Contacts

Rebuild American Web Site Address: http://www.eren.doe.gov/buildings/rebuild/ (from this address, click on "Products and Services," then on "Rebuild America Financial Services" to get to the Rebuild America Financial Services web pages).

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TABLE OF CONTENTS

PREFACE

This report assesses the impacts on Wisconsin's economy of reducing greenhouse gas emissions through investments in energy efficiency.This report will be used to provide information to decision-makers and interested stakeholders in discussing policy options for reducing greenhouse gas emissions.

This study is a cooperative effort of many organizations and individuals. The Rebuild America Program at the U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy provided funding for this project to the Consortium for Integrated Resource Planning, Engineering Professional Development, University of Wisconsin. Pat Hughes of Oak Ridge National Laboratory provided input to the project. Engineering Professional Development, University of Wisconsin provided on going support for this work. The Wisconsin Department of Natural Resources Bureau of Air Management with the support of its Director, Lloyd Eagan and Climate Change Specialist Eric Mosher also provided support and facilities for this project.The Leonardo Academy made completion of this project possible by providing additional staff resources. Finally, I want to recognize the outstanding work of Steve Clemmer, Steve Olson, and Tom Karman in preparing and supporting the development of this report.

Michael Arny, Chair, Study Steering Committee
Director, Consortium for Integrated Resource Planning, EPD, University of Wisconsin
and
Director, Leonardo Academy Inc.

February 23, 1998

EXECUTIVE SUMMARY

The international debate about the potential impacts of global climate change is increasingly moving beyond the science into the economics of emission reduction strategies and the policies that are needed to best mitigate potential impacts.The 1992 Rio Earth Summit initiated international efforts to reduce greenhouse gas emissions.As a result of the Rio Earth Summit, the United States Climate Change Action Plan was developed with the goal of reducing greenhouse gas (GHG) emissions to their 1990 levels by the year 2000.The 1997 Kyoto Conference on Climate Change has shifted the goals to reducing emissions 3 to 7 percent below 1990 levels in the 2010 time frame. Most climate change experts agree that significant actions will need to be taken to achieve these reductions. Between 1990 and 1996 GHG emissions rose 8 percent in the U.S., as strong economic growth and declining energy prices have increased energy use.

While ultimately an international issue, states have become increasingly active in climate change discussions. One of the main reasons for this involvement is that the federal government has looked to the states to implement initiatives to reduce greenhouse gases and other emissions. Wisconsin, like many other states, has played an active role in researching, developing and implementing mitigation strategies to reduce GHG emissions. Most of the research has focused on the direct costs and benefits of implementing these strategies with little information for decision makers on how these strategies affect the regional economy.

The purpose of this report is to examine the macroeconomic impacts of consumer and business investments in end use efficiency and end use fuel switching measures that reduce electricity use in Wisconsin. It does not analyze the economic impacts of investments in cleaner electric supply technologies or cleaner transportation measures. Wherever this report refers to efficiency and fuel switching measures it is referring to end use efficiency and end use fuel switching measures.

This study used as an input, the ranking of end use efficiency and end use fuel switching measures from the 1998 Greenhouse Gas Emission Reduction Cost Study prepared by the Wisconsin Department of Natural Resources, University of Wisconsin, Consortium for Integrated Resource Planning, and the Leonardo Academy Inc. (WDNR, 1998) with support from other state agencies and private organizations. The WDNR, 1998 report developed several GHG emission reduction scenarios based on screening the full range of emission reduction measures from a utility cost perspective.

The analysis of broader economic impacts of GHG emission reductions described in the current report investigates some of the emission reduction measures identified in the WDNR (1998) report, yet is different in three important aspects:

Executive Summary

- This analysis includes only end use electric energy efficiency and end use fuel switching measures installed in the residential, commercial, industrial, and agricultural sectors, because these comprised the majority of the low cost emission reduction measures identified in the DNR report.

- This analysis examines the impacts of implementing these measures from the consumer's perspective instead of the utilities' perspective, using retail electricity prices to calculate customer savings instead of utility avoided costs.

- This analysis uses a 53-industry dynamic economic forecasting and policy simulation model of Wisconsin's economy, developed by Regional Economic Models, Inc. (REMI) to measure economic impacts of energy efficiency investments. The REMI model captures the economic ripple effects that occur as money is respent by industries that are linked in Wisconsin's economy. The model is dynamic because it incorporates changes in prices, wage rates, demographics, regional productivity and other economic variables and tracks the impacts these variables have on employment, personal income and gross state product. This model is also used by the Wisconsin Department of Transportation (DOT) to carry out economic impact analyses of transportation projects.

This analysis investigates the economic impacts of two scenarios for investment in energy efficiency and fuel switching measures. The first scenario includes implementation of only cost effective measures. The second scenario includes implementation of all the measures that cost up to $100 per ton of CO_2 emission reduced.

The results show that the cost-effective scenario with investments of $1.75 billion in energy efficient technologies by Wisconsin residents, businesses and farmers would:

- Create 8,500 new jobs, $490 million in disposable income and $41 million in gross state product by 2010 (see Table 1).

- Reduce Wisconsin's greenhouse gas emissions by 7.7 million tons in 2010, which is 21 percent of the amount needed to reduce greenhouse gas emissions to their 1990 level.

- Reduce projected statewide electricity use in Wisconsin by more than 9 million megawatt hours in 2010. This is equivalent to displacing the electricity generated from five 265 megawatt power plants or consumed annually by over one million households.

EXECUTIVE SUMMARY

- Reduce the need for electric generation capacity additions by more than 1300 megawatts.

- Decrease energy and operating expenditures by $4.44 billion between 1997 and 2010. Given the investment of $1.75 billion needed to install the more efficient technologies for consumers and businesses during the same period, this amounts to a total net savings of $2.69 billion or a benefit-cost ratio of 2.7.

Figure 1 shows the overall impact on Wisconsin's economy of implementing the cost effective energy efficiency scenario relative to a business as usual scenario.The overall impacts are relatively small due to the level of investment considered in this analysis. In proportion to the rest of the economy, employment and income, are expected to grow by only 0.1 percent to 0.4 percent in 2010. Real disposable income increases steadily throughout the forecast period.

This occurs as cumulative energy savings exceed the higher capital cost consumers pay for more efficient technologies, which increases consumer purchasing power. Real

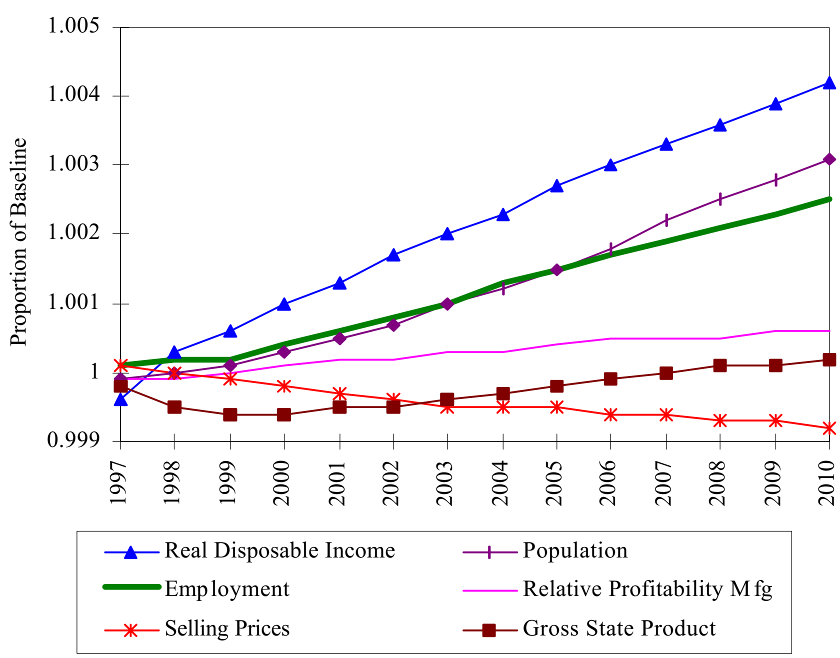

Fig. 1. Impacts on the Wisconsin economy of implementing the cost effective energy efficiency scenario relative to baseline of business as usual (relative changes in selected economic variables).

disposable income per capita (not shown) also increases throughout the forecast period as the income growth exceeds population growth and inward migration.

Energy savings in the residential and commercial sectors are the biggest drivers of employment and income growth. Energy savings in the residential sector increases disposable income, which leads to growth in employment as most of the income is spent locally on consumption of goods and services other than electricity. Energy savings in the commercial and industrial sectors lower the cost of doing business and can increase the competitiveness, productivity, and profitability of Wisconsin businesses. If other states do not capture the benefits of increased energy efficiency and all other factors affecting the cost of business remain the same, Wisconsin industry will increase their competitive advantage.

If businesses in other states also capture the benefits of increased energy efficiency and all other factors affecting the cost of business remain the same, Wisconsin businesses will retain their competitive position.

For industries that sell primarily in regional markets, energy savings are passed on to consumers through lower selling prices of goods and services. This stimulates further consumption and demand for intermediate inputs both locally and outside the region, which creates additional jobs and income. Furthermore, it causes exports and the percentage of goods supplied locally to increase while imports decline. For regional industries that sell primarily in national markets, electricity savings result in increased profitability.

Increased investments in energy efficient technologies would create jobs in nearly all Wisconsin's industries. This is because money would be shifted away from the capital intensive electric industry which exports a significant portion of its revenue to other regions to pay for fossil fuels, and toward more labor-intensive industries and greater local consumption of goods and services.

The service and retail trade industries would realize the greatest employment increase as consumers spend energy savings on consumption and service related activities (such as health care, lodging, amusements, restaurants, business services, auto repair, etc.). The local sale of energy efficient appliances and technologies generates job growth in retail and wholesale trade. The utility sector realizes a net loss in employment as electricity savings reduce the amount of electricity needed by consumers relative to the base case. The combined impact on jobs in the various sectors determines the overall impacts on employment in Wisconsin of the two scenarios which are shown in Table 1. Employment, real disposable income, and gross state product net of the utility

EXECUTIVE SUMMARY

Table 1. Economic impacts of Wisconsin electric energy efficiency and fuel switching investments in 2010

	All measures with a net cost per ton of CO_2 reduced up to	
Impact	$0/ton	$100/ton
Employment	8,526	7,255
Real disposable income (mil. 92$)	490	428
Gross state product (mil. 92$)	41	–42
GSP net of utility sector (mil. 92$)	323	266

sector increase in both scenarios. Gross state product rises by $41 million in the up to zero cost per ton case and declines by $42 million in the up to $100 per ton scenario.

Figure 2 shows that for the measures analyzed, the majority of the emission reductions identified (about 7.7 million tons or 89 percent of the total emission reductions) can be achieved at a net saving (at a net cost below $0 per ton) to Wisconsin's electricity consumers. A net savings means that the cumulative energy savings over the life of an energy efficient measure exceed the incremental investment and operating costs. Only 0.9 million tons of additional emission savings would be achieved by implementing the measures with net costs between $0 and $100 per ton of CO_2 reduced.

Implementation Issues: This study assumes that the increased investment in the more efficient technologies for consumers and businesses would be achieved at no extra cost to consumers beyond the higher capital cost for purchasing the more efficient technologies. This means that no program costs for causing the implementation of higher efficiency and fuel switching end use measures were included in this analysis.

An implementation program will be needed to stimulate the increased investment in the more efficient technologies, but the actual program costs will depend on the approach used for implementation of measures. Approaches to implementation are available that are effective and have low program costs. Such approaches would closely match to the assumptions used in this report.

For example, using increased equipment energy efficiency standards and increased building energy efficiency standards in building codes has low program costs, and high penetration rates that could deliver the emission reductions identified in this study. Other approaches to implementation can have higher program costs that

EXECUTIVE SUMMARY

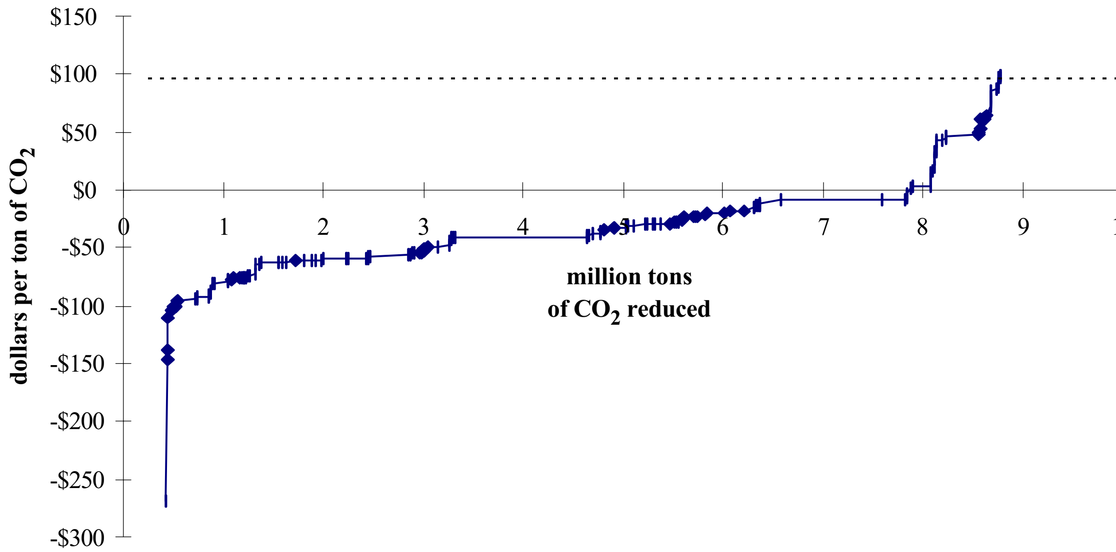

Fig. 2. The net cost of reducing greenhouse gas emissions. Each diamond represents one of 176 specific energy efficiency and end use fuel switching measures installed in the residential, commercial, industrial or agricultural sectors. See Appendix B for a list of specific measures, ranked by their net cost of reducing GHG emissions. Net cost is equal to the incremental investment and operating costs of an energy efficient measure compared to a standard efficiency measure minus avoided energy and capacity savings divided by emission reductions over the operating life of the measure. In this figure, the energy cost savings are taken from WDNR (1998) where they were calculated using a utility cost perspective.

significantly diverge from the assumptions used in this report and could affect the results of this study.

There is some room for covering program costs, given the direct cost savings between 1990 and 2010 and the increase in annual disposable income cost savings by 2010. Installing all the cost effective measures evaluated in this report would result in a cumulative net savings of $2.7 billion and a cumulative increase in disposable income of $3.3 billion between 1997 and 2010. Installing all measures costing up to $100 per ton of CO_2 reduced would result in cumulative net savings of $2.2 billion and a cumulative increase in disposable income of $2.5 billion between 1997 and 2010.

Alternative approaches to implementation are not considered in this report but will be considered in the development of a climate change action plan that reduces greenhouse gas emissions in Wisconsin. In this next phase, choosing approaches to implementation that are effective and low cost will provide the greatest economic benefits.

Possible Effects of Use of Generation Capacity Freed Up by the Efficiency Measures to Supply Loads Outside the State: Generation capacity freed up by the efficiency measures could be used to generate electricity to serve out of state loads. It is possible that the net generation freed up could be used to generate electricity for sale outside of the state. If this occurred it would increase the emissions from the generation plants in Wisconsin but decrease the emissions from the generation that would have otherwise served those out of state loads. This means that the electricity end use reduction measures decrease emissions somewhere, and the out of state electricity sales would simply change where these emission reductions occur. Since climate change is global in scope, the specific location of greenhouse gas emission reductions does not diminish the effectiveness of these emission reductions.

In summary: This study shows that installing cost-effective electric energy efficiency measures in Wisconsin's, homes, businesses and farms will lower greenhouse gas emissions produced from fossil fuel combustion while delivering employment and income benefits for Wisconsin. Installing these measures will produce net savings that increase disposable income for residents to spend on goods and services other than electricity. In addition, by lowering the cost of producing goods and delivering services, they increase the competitiveness, productivity and profitability of Wisconsin businesses. Furthermore, these technologies use less energy to deliver a similar or improved level of service (heating, cooling, lighting and drive power), comfort and convenience. Thus, these investments deliver overall benefits to individual residents and businesses as well as society.

Public policy decisions of what actions should be taken to reduce greenhouse gas emissions will need to balance the full range of costs and benefits of various levels of possible actions. This report was developed to contribute to the foundation for these public policy decisions.

Acronyms

CO_2	Carbon dioxide
ECW	Energy Center of Wisconsin
GSP	Gross state product
GHG	Greenhouse gas
kW	Kilowatt
kWh	Kilowatt-hour
MMBtu	Million British thermal units
O&M	Operation and Maintenance
REMI	Regional Economic Models, Incorporated
RPC	Regional Purchase Coefficient
USDOE	United States Department of Energy
WDOD	Wisconsin Demand-Side Options Database
WEB	Wisconsin Energy Bureau
WDNR	Wisconsin Department of Natural Resources

SECTION 1

INTRODUCTION

The international debate about the potential impacts of global climate change is increasingly moving beyond the science into the economics of emission reduction strategies and the policies that are needed to best mitigate potential impacts. Prominent economists have estimated that damages caused by global warming could cost the U.S. economy $55 billion to $111 billion in 2060 (Nordhaus, 1991; Cline, 1992; Titus, 1992; Tol, 1995; and Fankhauser, 1995). In February of 1997, a group of 2,100 economists, including six Nobel Prize winners, signed a statement asserting that steps can be taken to curb global warming that would not harm the U.S.'s economic health, and "may in fact improve" long-term economic productivity (Wall Street Journal, 2/13/97).

The issue of climate change has also attracted the attention of the insurance industry. Economic damages from weather-related natural disasters such as hurricanes, typhoons, floods, wind storms and fires, which are believed to be linked to climate change, reached a record $60 billion in 1996 (Berz, 1996). Total insured losses from weather-related disasters in 1996 were $9 billion, the fourth highest ever recorded—though well short of the record $23 billion in 1992, the year of Hurricane Andrew (Brown et al., 1997). The resulting claims have wreaked havoc on the insurance business.

The international community responded to the threat of global warming at the 1992 Rio Earth Summit by adopting the Framework Convention on Climate Change (FCCC). Over 160 nations signed the treaty initiating an international effort to reduce greenhouse gas emissions. The United States, which is responsible for 23 percent of global GHG emissions, committed to reducing greenhouse gas emissions to 1990 levels by the year 2000 when the Clinton Administration released the U.S. Climate Change Action Plan (CCAP). This plan recommends numerous specific measures, most of which are voluntary, to reduce greenhouse gas emissions.

Most climate change experts agree that it will be difficult for the U.S. to reduce greenhouse gas (GHG) emissions to their 1990 levels by the year 2000. In fact, U.S. greenhouse gas emissions rose eight percent between 1990 and 1996, as strong economic growth and declining energy prices caused energy use to increase. The 1997 Kyoto Conference on Climate Change has shifted the goals to reducing emissions 5 to 7 percent below 1990 levels in the 2010 time frame.

While ultimately an international issue, states have become increasingly active in climate change discussions. The federal government frequently has looked to the states to implement CCAP and other initiatives to reduce greenhouse gases and other emissions. Thus, states have an interest in influencing international negotiations since they will be

SECTION 1

directly affected by them. Furthermore, the states can use the experience they have already gained to help identify the most effective strategies.

A number of state and national studies have shown that cost-effective investments in energy efficiency measures can significantly reduce emissions and stimulate economic growth (e.g. Sanghi, 1992; Krier et al., 1993; Laitner, 1994 and 1991; Geller, 1992; and Weisbrod, 1995). However, the results of these studies are not fully transferable to Wisconsin due to differences in economic conditions, energy resource use and energy prices.To provide state decision-makers with a more complete picture of the potential impacts of climate change policies, this report assesses the impacts on Wisconsin's economy of reducing greenhouse gas emissions through investments in energy efficiency.

Background

Through a grant from the U.S.EPA, an interagency committee in Wisconsin has completed an inventory of greenhouse gas emissions (WDNR, 1993) and estimated the costs and benefits of various emission reduction strategies (WDNR, 1998).This research concluded that fossil fuel consumption produced 89 percent of Wisconsin's greenhouse gas emissions in 1990. As shown in Fig. 1-1, the two largest consumers of fossil fuels—electric utilities and transportation—produce two-thirds of this total.The electric utility emissions result from three factors: the amount of electricity used by consumers, the types of generation chosen by utilities, and the types of fuels chosen by utilities. For this reason, both the perspective of the amount of emissions leaving power plant utility smoke stacks and the perspective of the amount of emissions result from consumer use of electricity provide some insights. Both perspectives are show in Figs. 1-1 through 1-4.

For Wisconsin to do its part in reducing greenhouse gas emissions to 1990 levels, emissions would have to be reduced by about 12 million tons in 2000 and 37 million tons in 2010. In the WDNR greenhouse gas emission reduction cost study, cost-effective investments in electric energy efficiency technologies by Wisconsin residents, businesses and farmers were shown to move Wisconsin 23 percent of the way toward reducing greenhouse gas emissions produced in the state to 1990 levels by the year 2010 at an overall net savings to consumers (WDNR, 1998). Because emission reductions in the transportation sector were shown to be more costly and difficult to achieve at the state level than in the electric sector, this study focuses on the economic impacts of reducing GHG emissions from electricity generation by installing energy efficiency and fuel switching measures.

In addition to its environmental effects, energy use is a major cost in Wisconsin's economy. In 1996, Wisconsin's total energy bill was $9.6 billion, which is equivalent to about

SECTION 1

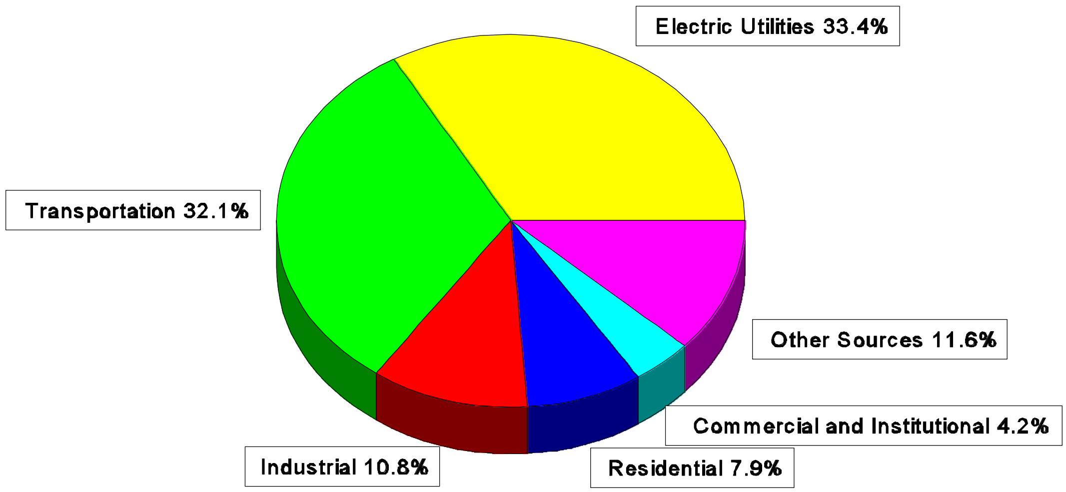

Fig. 1-1. 1990 GHG emissions by emitting sector. 141 million short tons total.

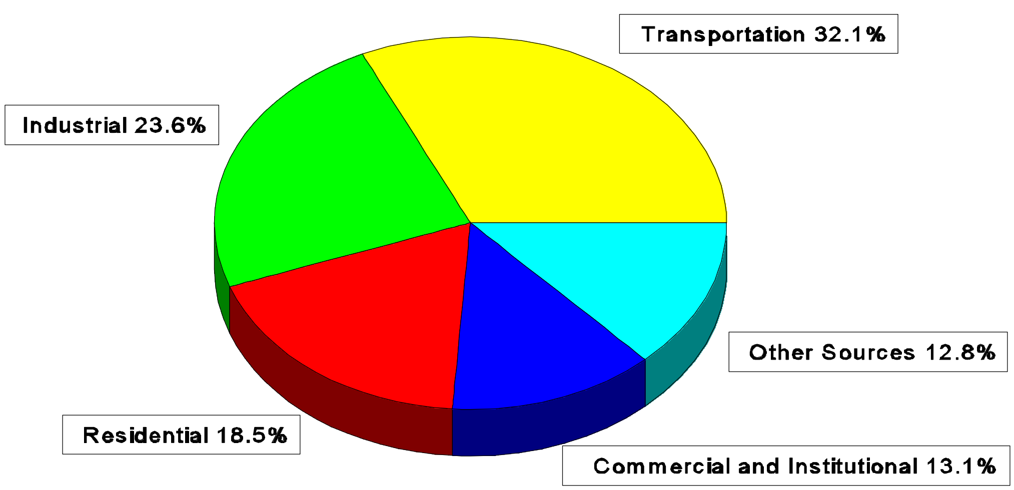

Fig. 1-2. 1990 GHG emissions from consumption by end use sector. 141 million short tons total.

SECTION 1

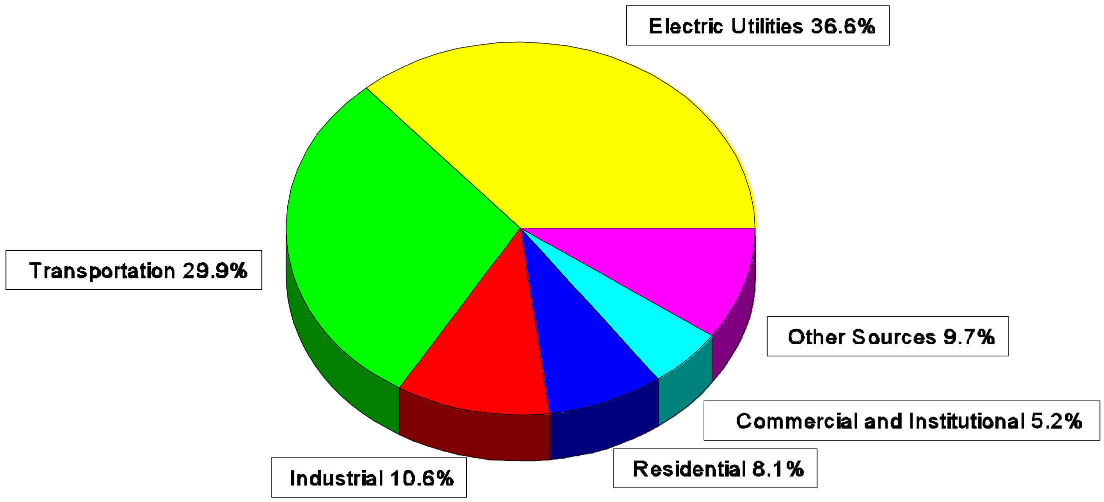

Fig. 1-3. 2010 GHG emissions by emitting sector. 181 million short tons total. *Source:* Greenhouse Gas Reduction Cost Study (WDNR 1998).

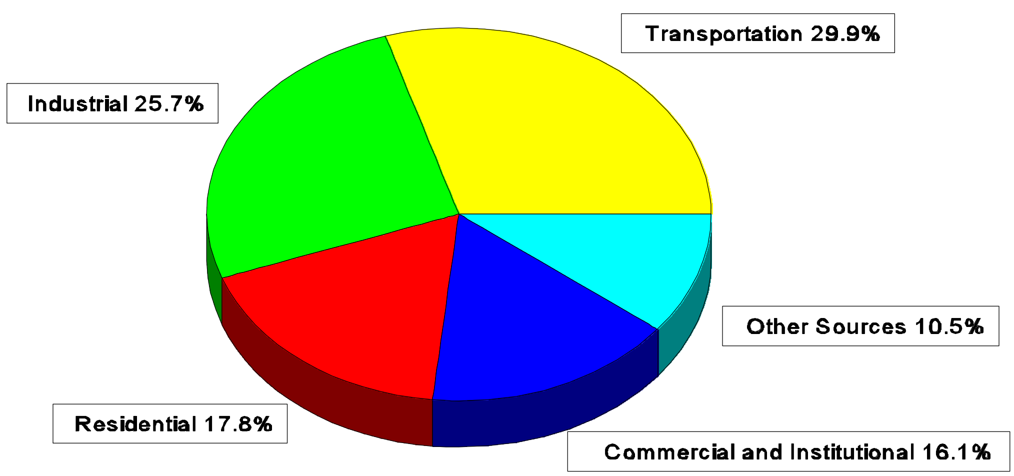

Fig. 1-4. 2010 GHG emissions from consumption by end use sector. 181 million short tons total. *Source:* Greenhouse Gas Reduction Cost Study (WDNR 1998).

SECTION 1

seven percent of gross state product or $1,870 for every person living in the state. Fossil fuel costs are a significant part of Wisconsin's overall energy bill, and Wisconsin imports about 96 percent of the energy resources to meet its energy needs in the form of fossil fuels. This results in Wisconsin exporting over $7 billion of its total energy bill to other fossil fuel producing states and countries. This lost economic opportunity of $1,360 for every person in Wisconsin is larger than the annual sales of the state's forest products, agriculture and tourism industries.

Wisconsin, which is responsible for two percent of U.S. GHG emissions, has adopted policies and implemented programs to address climate change issues. For example, Wisconsin's state energy policy directs government and encourages residents and businesses to save energy and use renewable energy before turning to fossil fuels in order to improve environmental quality and create jobs (1993 Wisconsin Act 414). In addition, the Public Service Commission of Wisconsin requires the state's electric utilities to add a cost of $15 per ton of carbon dioxide emitted for planning purposes when comparing and selecting electric generating technologies in the state's Advance Planning process. Furthermore, various state agencies, utilities and industries in Wisconsin are participating in several of the U.S. Climate Change Action Plan programs. These programs include: Climate Wise, National Industrial Competitiveness through Energy, Environment, and Economics (NICE^3), Green Lights, Landfill Methane Outreach, Rebuild America, Motor Challenge, Climate Challenge, Energy Star and Home Energy Rating Systems.

Report Organization

The report begins with a brief review of state and national studies that have measured the economic impacts of strategies to reduce emissions. Section 2 also describes the assumptions, the model, and the scenarios that were used to calculate the economic impacts of reducing greenhouse gas emissions in Wisconsin through investments in efficient electric technologies. Section 3 identifies how these investments affect employment, income, gross state product and other economic variables in Wisconsin. The final section summarizes the major conclusions of the report, and offers suggestions for additional research.

SECTION 2

METHODOLOGY

Literature Review

Numerous state and national studies have analyzed the economic and emission impacts of investing in energy efficiency. Most of these studies have shown a positive correlation between energy savings and emission reductions, increased employment and economic activity. However, the results of this previous research are not directly transferable to Wisconsin due mainly to differences in economic conditions, energy resource use and energy prices. In addition, many of these studies have used static input-output multiplier models to calculate economic impacts (e.g. Sanghi, 1992; Krier et al., 1993; Laitner, 1994 and 1991; and Geller, 1992). These models are based on a snapshot of the economy at one point in time, which only make them useful for short-term analysis. Furthermore, they do not capture the long-term macroeconomic effects that result from changes in business competitiveness and productivity, wage rates, prices and other economic variables. See Weisbrod (1995) for a more thorough review of economic impact studies of energy technologies and a description of the differences between dynamic macroeconomic models and static input-output models.

Of particular interest to Wisconsin, two studies have quantified the direct costs and benefits of strategies to reduce greenhouse gas emissions (Center for Clean Air Policy, 1995 and WDNR, 1998). These studies relied on data from the Energy Center of Wisconsin (1994), which developed an estimate of the statewide technical and economic potential for reducing electricity use through investments in efficient technologies. While these traditional cost-benefit analyses provide important information to decision makers, they do not address the full range of economic impacts that occur as the direct costs and benefits ripple through all industries that are linked in Wisconsin's economy.

Two Wisconsin studies have addressed the full economic impacts of investments in energy technologies. Using an input-output model, Laitner (1991) showed that investments in electric energy efficiency measures would generate employment, income and output in Wisconsin. While this analysis was insightful, it did not address impacts on specific industries and emission levels or long-term impacts on Wisconsin's economy. The Wisconsin Energy Bureau (Clemmer, 1995) used a dynamic economic and demographic forecasting and policy simulation model to quantify the long-term employment and income effects of increasing renewable energy use in Wisconsin. This study builds on the methodology used in the Energy Bureau study and the data collected in the WDNR (1998) greenhouse gas emission reduction study to calculate the economic impacts of investing in energy efficiency in Wisconsin.

SECTION 2

Model Selection

A 53-industry dynamic economic forecasting and policy simulation model of Wisconsin's economy, developed by Regional Economic Models, Inc. (REMI), was used to calculate the economic impacts of investing in energy efficient technologies. The REMI model captures the economic ripple effects that occur as money is respent by industries that are linked in a regional economy. The model is dynamic because it incorporates changes in prices, wage rates, demographics, regional productivity and other economic variables and tracks the impacts these variables have on employment, personal income and output.

The REMI regional economic model incorporates:

- inter-industry transactions and includes the effects of final demands for goods and services on these transactions,
- substitution among the various factors of production in response to changes in expected income,
- wage responses to changes in labor market conditions, and
- changes in the share of local and export markets in response to changes in regional profitability and production costs.

The REMI model is similar to traditional computable general equilibrium models in that it includes the use of price-responsive products and factors of demands and supplies. However, the REMI model is different from the traditional computable general equilibrium models in that the product and factor markets do not clear continuously. Instead, the time paths of responses between variables are modeled. (Summarized from a description of the model by Lieu and Treyz (1995).

The REMI model incorporates inter-industry transactions from the national input-output table and projections from the U.S. Department of Commerce, Bureau of Economic Analysis, and makes adjustments to fit Wisconsin specific conditions. Adjustments are made based on the relative strength of various industries in Wisconsin and the relative cost of doing business for each of these industries compared to the U.S.. Wisconsin historical economic data and trends from 1969-1995 are also incorporated into the model. The REMI model is used by numerous state governments including Wisconsin. In Wisconsin, the REMI model is used by the Wisconsin Department of Transportation to conduct economic impacts analyses of transportation projects. A number of peer reviewed articles have been published about the REMI model. (Treyz, Rickman, and Shao. 1992)

SECTION 2

Framework for Analyzing the Economic Impacts of Investments in Increased Energy Efficiency and Fuel Switching Measures

Three major steps are necessary for assessing the economic impacts of investments in increased energy efficiency and fuel switching measures:

1. Complete a baseline economic forecast of the regional economy.
2. Identify the direct ways in which investments in energy efficient technologies will affect Wisconsin's economy.
3. Input these changes in direct expenditures into the model and run an alternative forecast to capture the total economic impacts.

These steps are discussed in detail below.

Step 1: Completing a baseline economic forecast for Wisconsin

The REMI model was used to create a baseline economic forecast for Wisconsin. Table 2-1 illustrates the REMI model baseline projections for key variables in Wisconsin's

Table 2-1. REMI baseline forecast of Wisconsin's economy

					Average annual growth rate		
	1997	2000	2005	2010	1997–2000	2000–2005	2005–2010
Gross state product (bil. 92$)	139.931	147.947	160.120	174.489	1.9%	1.6%	1.7%
Disposable personal income (bil. 92$)	100.490	104.970	111.575	117.484	1.5%	1.2%	1.0%
Employment	3,186,495	3,246,852	3,310,608	3,355,053	0.6%	0.4%	0.3%
Population	5,130,230	5,122,193	5,095,099	5,115,839	–0.1%	–0.1%	0.1%
Employment by sector							
Durable goods manufacturing	376,311	363,631	334,411	310,335	–1.1%	–1.7%	–1.5%
Nondurable goods manufacturing	239,597	236,430	231,037	225,241	–0.4%	–0.5%	–0.5%
Mining	3,427	3,205	2,898	2,639	–2.2%	–2.0%	–1.9%
Construction	143,057	143,817	146,184	149,361	0.2%	0.3%	0.4%
Transportation & communication	122,171	123,795	124,581	115,457	0.4%	0.1%	–1.5%
Public utilities	17,562	17,552	17,358	17,409	0.0%	–0.2%	0.1%
Finance, insurance & real estate	211,030	215,855	223,300	224,401	0.8%	0.7%	0.1%
Retail trade	558,478	567,901	559,601	550,539	0.6%	–0.3%	–0.3%
Wholesale trade	136,662	135,353	129,565	126,174	–0.3%	–0.9%	–0.5%
Services	857,832	926,824	1,036,859	1,129,059	2.6%	2.3%	1.7%
Agriculture, forestry & fishery services	30,015	31,268	33,465	35,963	1.4%	1.4%	1.5%
Farm	104,992	97,276	84,129	80,006	–2.5%	–2.9%	–1.0%
State and local government	337,144	337,854	343,238	342,990	0.1%	0.3%	0.0%
Federal government	48,218	46,050	43,981	45,481	–1.5%	–0.9%	0.7%

Source: Wisconsin REMI model.

SECTION 2

economy.This forecast provides a basis for analyzing the relative magnitude of economic impacts that result from investments in energy efficiency measures and how specific sectors may be affected.

The forecast shows relatively stable growth of 1-2 percent per year in gross state product and real disposable income.While total employment increases slightly, employment by sector varies widely.The largest growth in employment occurs in the service sector, which out-paces employment losses in manufacturing, mining, farming, transportation and communication.Employment in the utility sector, which is most adversely affected by the increased end use energy efficiency and end use fuel switching investments, constitutes 0.5% of the statewide total and remains stable over the forecast period.

Step Two: Identifying the direct ways in which consumer investments in increased energy efficiency and fuel switching measures will affect Wisconsin's Economy

To develop a complete and unbiased analysis, it is important to account for all the direct increases and decreases in expenditures that result from a change in policy. Policies designed to provide savings to certain sectors of the regional economy most often result in losses to other sectors.The four major direct effects that occur due to energy efficiency investments are described below.The total economic ripple effects that result from the combination of these four direct changes in expenditures equals the net impact on Wisconsin's economy.

- Investment Impact. This is the initial incremental cost made by energy consumers (residential, industrial, commercial, and agricultural) in efficient technologies such as lighting, furnaces, air conditioning and motors.Total incremental investment costs are broken down and associated with the appropriate industries in Wisconsin that manufacture, distribute, sell and install energy efficient technologies. These expenditures are adjusted using regional purchase coefficients (RPCs), which are the percentage of these goods and services that will be provided from industries within Wisconsin.

- Spending Impact. Investments in more efficient technologies reduce energy consumption and therefore lower energy bills.This affects the spending patterns of households and businesses.For households, bill savings increase disposable income, which increases consumption of goods and services other than energy. For businesses, energy bill savings lower the cost of doing business, which can reduce the selling prices of goods and services, increase profitability and create new investment opportunities.For industries that sell primarily in regional markets, the REMI model assumes that savings are passed on as a reduction in the selling price of goods and services. Because prices are based on relative production costs within the region, the REMI model assumes that regional industries will lower selling prices to maintain an advantage over competitors both inside the region and in neighboring regions. For industries that sell primarily in national and international markets, the REMI model assumes that the savings result in increased profits. This is because these industries can continue selling their products and services based on the average national production costs. Energy savings to businesses and households are modeled net of incremental investment and operating costs.

- Displacement Impact. Electricity savings for customers due to energy efficiency and fuel switching result in reduced sales and revenues for electricity generators. This reduces the long-term demand for electricity, which results in less money spent on building, operating and maintaining new power plants and transmission lines in Wisconsin. In this report, it was assumed that energy efficiency improvements will mainly reduce the need for new power plants and transmission lines in Wisconsin and potentially reduce some generation from existing power plants, including plants that are scheduled for retirement. Furthermore, it was assumed that most of electricity displaced (an adjustment is made for electricity imports) will reduce sales growth for Wisconsin electricity providers compared to the baseline and thereby result in reduced growth of jobs and income in Wisconsin's electric utility sector.

However, it is possible that any generation displaced from existing plants (not including retired plants) could be sold outside of Wisconsin. If this occurred, the reduced growth in jobs and income in the utility sector would not be as large as shown in this study, and overall economic benefits to the state would increase.

- Energy Price Impact. Consumer investments in increased energy efficiency and fuel switching could increase or decrease the price of electricity for all consumers depending on a number of factors. Under traditional rate based regulation, the price of electricity could increase in the short-term if electricity use reductions exceed the growth in electricity sales as the fixed costs of utility investments are spread across fewer kilowatt-hours. Under traditional rate based regulation, the price of electricity could decrease if electricity use reductions only reduce the growth in electricity sales, since increased energy efficiency decreases the need for additions to the generation, transmission, and distribution system.

In this study, retail electricity prices were assumed to be the same as the baseline forecast due to the uncertainty created by electric utility restructuring in Wisconsin and nationally. Research by the Public Service Commission of Wisconsin (1995) shows that if electricity customers in Wisconsin and other states had the ability to choose their electric providers, long-term electric rates in Wisconsin could potentially increase or decrease depending on a number of factors. In addition, individual customer classes most likely would be affected differently. Despite this uncertainty, the measures investigated in this study should result in a long-term reduction in electricity prices compared to the baseline because the incremental cost per kilowatt-hour of electricity saved is projected to be lower than the cost of new electricity generation, transmission and distribution investments per kilowatt-hour delivered.

Discussion of Key Input Assumptions Used in the Analysis of the Economic Impacts of the Energy Efficiency and Fuel Switching Investment Scenarios

The key assumptions used to select and evaluate measures in the WDNR (1998) report that were adopted and modified in some cases for this analysis are explained below. This enhances the understanding of the potential electricity savings, emission reductions and economic benefits estimated in this report and that could be available under different assumptions.

1) The energy efficiency and fuel switching scenarios used in this report were selected using the analysis of measures in the Wisconsin GHG Emission Reduction Cost Study, (WDNR 1998). (See Appendix B for a list of the specific measures ranked by their net cost of reducing greenhouse gas emissions.) The WDNR study analyzed hundreds of specific energy efficiency and fuel switching measures for different market segments and end uses within the residential, commercial, industrial and agriculture sectors based on data from Wisconsin's Demand-Side Options Database (WDOD). The WDOD information was developed collectively by Wisconsin's utilities for use in the state's integrated resource planning process (ECW, 1994).

The WDNR study produced conservative estimates of energy efficiency and fuel switching potential and GHG emission reductions. For comparison, the WDNR study captured only 54 percent of the statewide economic energy efficiency and fuel switching potential that had been identified for Wisconsin's integrated resource planning process in 1995 (ECW, 1995).

2) Wisconsin electricity consumers are assumed to replace existing appliances and equipment with higher efficiency or fuel switching equipment when they wear out or when new appliances or equipment are needed for new applications. For each type of appliance or equipment, the upgrades to higher efficiency or fuel switching equipment are assumed to occur in equal yearly proportions over a period of time equivalent to twice the specific appliance or equipment's "average" lifetime. Since the analysis covered a 14 year time frame, only a portion of the eligible population of existing appliances and equipment with average lifetimes greater than 7 years were assumed to be replaced

SECTION 2

by an energy efficient measure. If, for example, it was assumed that all appliances and equipment wear out and need to be replaced over a period equal to one and a half times their average life time, a larger reduction in energy use and emissions would have resulted.

3) The potential effects of early replacements of existing appliances and equipment with higher efficiency units before the existing appliances and equipment wear out was not addressed in this analysis. Early replacements of existing appliances and equipment would result in larger electricity and emission savings. However, early replacement would require more aggressive implementation efforts and higher implementation costs.The costs and benefits of early replacements were not investigated in this analysis.

4) It was assumed that only the technology with the lowest net cost per ton of CO_2 reduced out of multiple replacement options would be selected to replace an existing technology.The analysis did not consider the additional savings that could be obtained through combined measures such as replacing an electric water heater with a natural gas water heater and installing a low-flow showerhead and faucet aerators.

5) Several types of industrial process improvements and residential and commercial whole building increased energy efficiency and fuel switching measures such as integrated heating, cooling, lighting and building shell improvements were not considered.These areas would provide additional opportunities for increased energy efficiency and fuel switching if they had been investigated.

6)The population of replacement technologies in the cost range of $0 to $100 per ton of CO_2 reduced was sparse.This is because an effort was made to identify only the most cost-effective energy efficiency and fuel switching measures when the data were collected for the Wisconsin Demand-Side Options Database (WDOD). If in the future a similar level of effort was expended to identify the full range of higher cost options, additional measures in the $0 to $100 per ton cost range would be identified.

7) The ongoing development of technical innovation and commercialization of new energy efficiency and fuel switching measures was not assumed.This analysis is limited to the best measures available between 1992 and 1995, when the WDNR 1998 analysis was carried out and when the WDOD data base was developed.

This ignores the historical trend of continuing technological innovation which has continued since 1995. New and improved technologies that are more efficient than those available between 1992 and 1995 continue to be developed and commercialized.

SECTION 2

8) This analysis includes 100 percent of the cost of the investments in energy efficient technologies through the end of the study period in 2010. However, it does not include 100 percent of the energy savings that these investment produce over their lifetimes. Specifically, the approach used does not capture the savings that occur after 2010 as the result of measures installed before 2010 which have lifetimes that extend beyond 2010. Not capturing all the savings of these measures while including all the investment costs, results in exaggerating the net cost of reducing greenhouse gas emissions and underestimating the long-term economic benefits of investing in energy efficient technologies.

9) Only a small number of industrial sector energy efficiency, fuel switching and process improvement measures were included in this analysis. This is due to information on specific industrial efficiency measures not being available at the time the study was prepared. Industrial sector energy efficiency and fuel switching measures and process improvements are typically very specific to individual industrial facilities and, as a result, can be difficult to include in an analysis of generally applicable measures. Thus, the potential electricity savings, emission reductions and economic benefits estimated for the industrial sector in this report are most likely underestimated. In the future it would be worthwhile to further investigate the industrial sector potential.

10) This study used the screening analysis from the Wisconsin GHG Emission Reduction Cost Study (WDNR 1998) to select measures to include in the scenarios investigated. The WDNR 1998 study carried out this screening analysis using a utility avoided cost perspective approach. The current study uses a consumer investment and consumer savings perspective to evaluate the economic impacts of these measures. If a consumer cost perspective had been used in the screening to select measures, it is likely that additional measures would have been identified and included at each cost level in the current analysis because consumer savings from energy efficiency investments result from the consumer's retail rates which are higher than the utility avoided costs.

11) This study assumes that the increased investment in energy efficiency and fuel switching measures would be achieved at no extra cost to consumers beyond the potentially higher capital cost for purchasing these measures. This means that no costs for the implementation of higher efficiency and fuel switching measures were included in the analysis carried out for this report. Some implementation mechanism will be needed to cause the increased investment in energy efficiency and fuel switching measures to occur, and the actual program costs for implementation will depend on the mechanism chosen. Some approaches to implementation have low program costs and are a close match to the assumptions used in this report. For example, implementation through increased equipment energy efficiency standards and increased energy efficiency standards in building codes would be effective and have low program

cost. Other approaches to implementation have higher program costs significantly diverging from the assumptions used in this report and would affect the results of this study. There is some room to pay for implementation program costs, given the net direct cost savings to consumers and increased disposable income.

Alternative approaches to implementation, will be considered during the next phase: the development of a climate change action plan to reduce greenhouse gas emission in Wisconsin. Choosing low cost and effective implementation approaches will maximize the net savings.

Scenario Development

Using the screening of energy efficiency and fuel switching measures from WDNR 1998 and the assumptions described above, two scenarios were developed based on measures with a net cost up to $0 and $100 per ton of CO_2 reduced. A description of the screening methods used in the WDNR 1998 study is included in Appendix A and the results of the WDNR screening showing the specific measures ranked by their net cost of reducing greenhouse gas emissions are included in Appendix B.

Figure 2-1 shows that for the measures analyzed, about 7.7 million tons or 89 percent of the total emission reductions from end use energy efficiency and end use fuel switching, can be achieved at a net saving (below $0 per ton) to Wisconsin's electricity consumers. Net savings means that the cumulative energy savings over the life of an energy efficient measure exceed the incremental investment and operating costs. Only 11 percent of more emission reductions would be achieved from measures with net costs between $0 and $100 per ton of CO_2 reduced.

Figure 2-2 shows that most of the electricity savings identified for the up to $0 per ton of CO_2 reduction scenario come from investments in the residential and commercial sectors. As explained above, the industrial sector electricity savings are small due to a lack of sufficient data on industrial sector energy efficiency, fuel switching and process improvement measures. Since the agricultural sector only uses about 3 percent of the electricity sold in Wisconsin, electricity savings in the agricultural sector will have a relatively low impact on overall Wisconsin emissions compared to other sectors.

Step Three: Input the Changes in Direct Expenditures into the REMI Model and Run Alternative Forecasts to Capture the Total Economic Impacts

Development of Consumer Perspective Investments and Data Preparation

To calculate the statewide employment and income effects of consumer investments in energy efficiency and fuel switching measures, changes in consumer spending must be developed and entered into the REMI model. This consumer perspective analysis is

SECTION 2

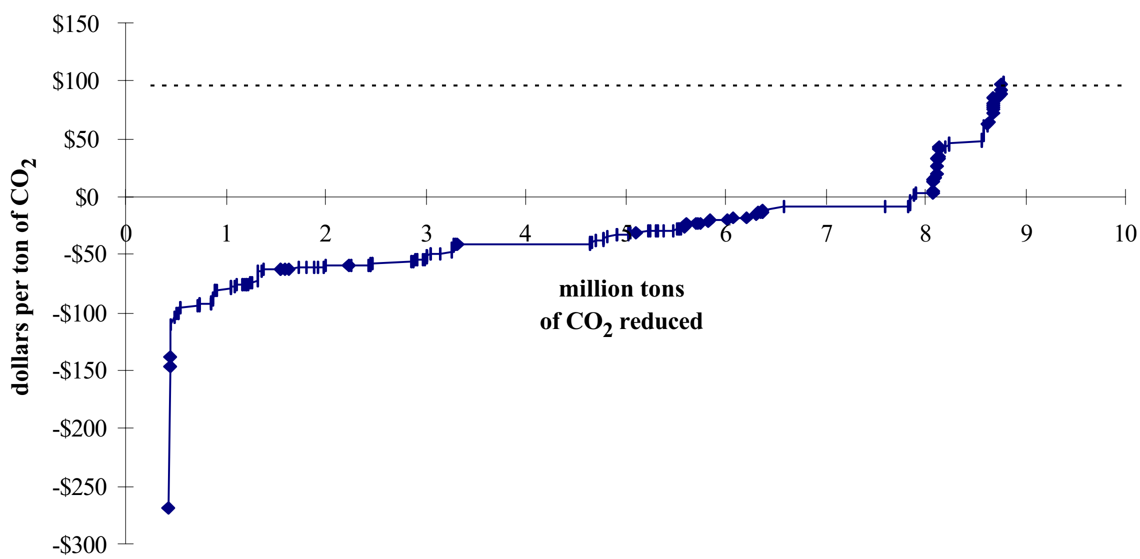

Fig. 2-1. The net cost of reducing greenhouse gas emissions through energy efficiency and end use fuel switching measures. *Source:* From the WDNR 1998 study using a utility cost perspective analysis. Each diamond represents one of 176 specific end use energy efficiency and end use fuel switching measures installed in the residential, commercial, industrial or agricultural sectors. See Appendix B for a list of these specific measures ranked by their net cost of reducing greenhouse gas emissions. Net cost is equal to the incremental investment and operating costs of an energy efficient measure compared to a standard efficient measure minus energy and capacity savings divided by emission savings over the operating life of the measure.

different from the approach used for the cost screening of measures in WDNR 1998 report described above, which calculated electricity cost savings for each measure from a utility avoided cost perspective.While utility perspective analysis is an effective approach for comparing the relative cost of utility alternatives, it does not accurately reflect the savings retail electricity consumers will realize from installing energy efficiency and fuel switching measures. For this reason, in this study the energy bill savings for each of these measures were recalculated using retail electricity and natural gas prices for each customer class (residential, commercial, industrial, and agriculture) to reflect reductions in consumer spending for energy.The retail electricity and natural gas prices were based on data from the Wisconsin Energy Bureau Energy Price Projections for Wisconsin (1995).

Table 2-2 illustrates the total direct costs and benefits (based on retail energy prices) of electric energy efficiency and fuel switching investments from 1997-2010 under the $0 and $100 per ton of CO_2 reduced scenarios.

SECTION 2

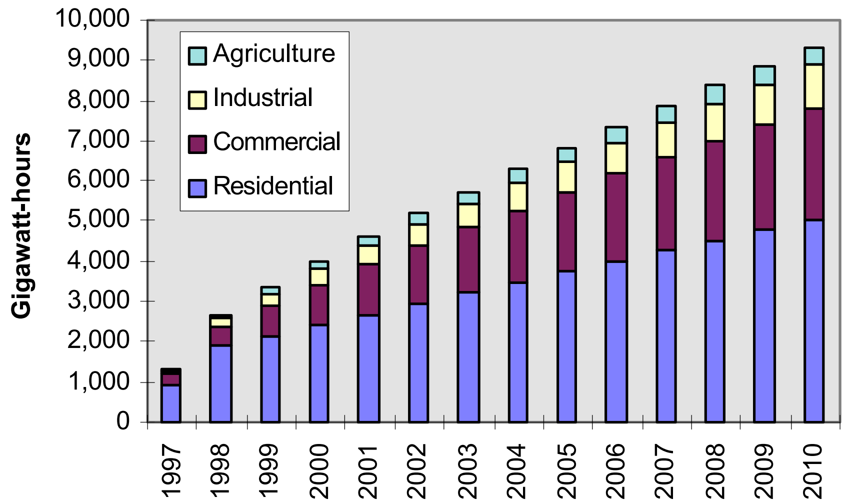

Fig. 2-2. Electricity savings, by sector ($0/ton of CO_2 reduced scenario). *Source:* From the WDNR 1998 Study Which Used a Utility Cost Perspective.

Table 2-2. Direct costs and benefits of energy efficiency and fuel-switching investments to Wisconsin electricity consumers, 1997–2010
(million 1992$)[1]

	All measures with a net cost per ton of CO_2 reduced up to	
Impact	$0/ton	$100/ton
Incremental investment costs	1,750	2,331
Incremental O&M costs (2)	–190	8
Change in costs due to energy savings (3)	–4,249	–4,521
Net change in costs due to energy savings (3)	–2,689	–2,182
Benefit/cost ratio	2.7	1.9

Notes: Energy savings are based on retail electricity and natural gas prices. (2) O&M savings realized under the $0/ton scenario are mainly due to the installation of energy efficient lighting in the commercial sector. (3) Energy savings after 2010 are not included.

SECTION 2

Net energy savings were calculated by subtracting the incremental investment and operating costs (for fuel switching measures). These costs and savings were allocated to different sectors in Wisconsin's economy based on their relative electricity use. Using customer level retail energy costs shows that there are net benefits to customers from implementing these measures. Under the $0 per ton scenario, investments by Wisconsin's electricity consumers produce $2.7 billion in net energy savings for a benefit-cost ratio of 2.7. Combining these investments with measures costing up to $100 per ton of CO_2 reduced results in lower net energy savings of $2.2 billion and a benefit-cost ratio of 1.9. These figures do not include energy savings that occur after 2010.

Table 2-3 shows that by 2010, implementing the cost effective energy efficiency scenario would provide 21 percent of the emissions reductions needed to reduce Wisconsin greenhouse gas emissions to their 1990 level. This is equivalent to displacing the electricity and emissions generated from five medium size (265 megawatt) power plants or consumed annually by over one million households. Implementing the up to $100 per ton scenario would provide 23 percent of the emissions reductions needed to reduce Wisconsin greenhouse gas emissions to their 1990 level.

Using this information on direct impacts the REMI model was run for the scenario composed of measures that are cost effective and for the scenario composed of measures costing up to $100 per ton. The results of this analysis are described in the next section.

Table 2-3. Energy and emission impacts in 2010

	All measures with a net cost per ton of CO_2 reduced up to	
Impact	$0/ton	$100/ton
Electricity savings (gWh)	9,327	10,097
Electric capacity savings (MW)	1,324	1,463
Natural gas increase [trillion (10^{12}) Btu]	11.0	11.4
GHG emission reductions (million tons)	7.7	8.4
Progress toward reducing emissions to 1990 level	21%	23%

SECTION 3

RESULTS

Impacts of $0 per ton of CO_2 Reduced Scenario

Table 3-1 illustrates that cost effective investments in energy efficient technologies by Wisconsin residents, businesses and farmers will create 8,526 new jobs, $490 million in disposable income and $41 million in gross state product above baseline projections in 2010. While economists often use gross state product (GSP) to measure overall economic activity and consumer well-being, a modification must be made in the case of energy efficiency. Investments in energy efficient technologies reduce consumption of electricity, which lowers the electric utility industry's contribution to GSP. It also increases the consumption of other goods and services and their contribution to GSP. However, the reduction in electricity production does not typically mean a reduction in the effective service received. In other words, electricity consumers experience a similar and often improved level of comfort, light, motion and power by investing in more efficient technologies. Thus, there is little loss and potentially a gain in consumer well-being that is not reflected in the net impact estimates of GSP (Moscovitch, 1994).

Since the value consumers receive from electricity remains essentially unchanged, the change in consumer well-being should therefore be measured by observing changes in GSP net of the electric utility sector. Using this measure, the overall welfare effect of energy efficiency is the change in the economy's production of goods and services other than electricity. Table 3-1 shows that, after an initial decline, total GSP is projected to rise throughout the forecast period to $41 million in 2010 when full investment would be attained. In the same year, the GSP net of the utility sector is projected to rise by $323 million.

Figure 3-1 shows that the level of investment in energy efficiency considered in this analysis has a relatively small impact on Wisconsin's overall economy. In proportion to the rest of the economy, employment and income, are expected to grow by only 0.1 percent to 0.4 percent in 2010. Real disposable income is projected to increase steadily

Table 3-1. Economic impacts of electric energy efficiency investments in Wisconsin

(all measures costing up to $0 per ton of CO_2 reduced)

Economic impact	2000	2005	2010
Employment	1,288	4,836	8,526
Real disposable income (millions 92$)	101	297	490
Gross state product (millions 92$)	–84	–35	41
GSP net of utility sector (millions 92$)	52	181	323

SECTION 3

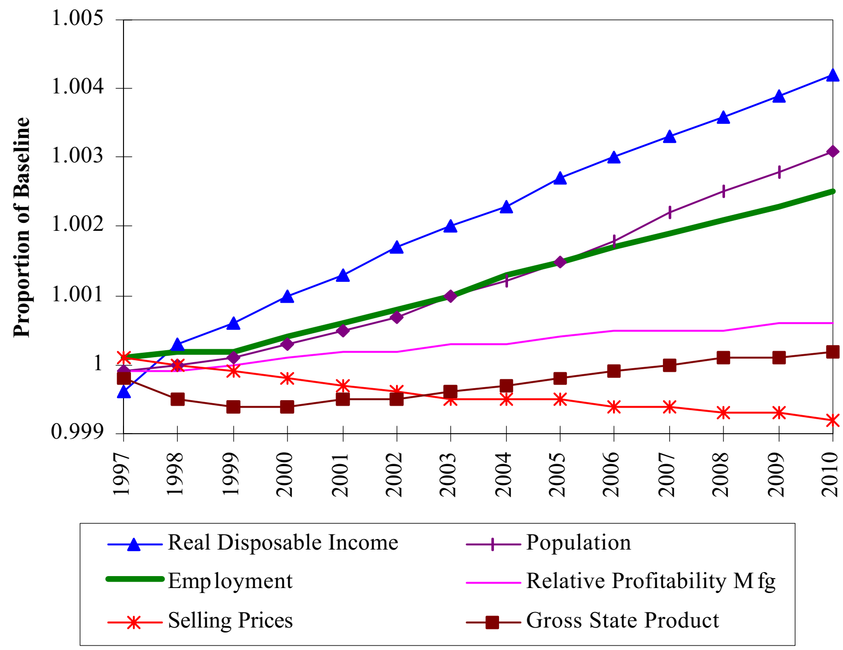

Fig. 3-1. Impacts on the Wisconsin economy of implementing the cost effective energy efficiency scenario (for selected economic variables relative to the baseline).

throughout the forecast period. This occurs as cumulative energy savings exceed the higher capital cost consumers pay for more efficient technologies. This increases consumer purchasing power. Real disposable income per capita is also projected to increase throughout the forecast period, peaking in 2010, as the growth in income exceeds the growth in population.

Figure 3-2 illustrates total jobs created in all sectors in Wisconsin as a result of energy efficiency and fuel switching investments in the agricultural, industrial, residential, and commercial sectors. Energy savings in the residential and commercial sectors are the biggest drivers of all sector employment and income growth. Commercial sector investments generate 58 percent of the new jobs created in all sectors as well as 30 percent of the electricity savings. Residential sector investments generate 31 percent of the total new jobs in all sectors as well as 54 percent of the electricity savings. The commercial sector investments generate greater employment and economic activity than residential sector investments because the measures implemented in the commercial sector have a higher saving to investment ratio and the service industries included in the commercial sector are more labor intensive than other industries.

SECTION 3

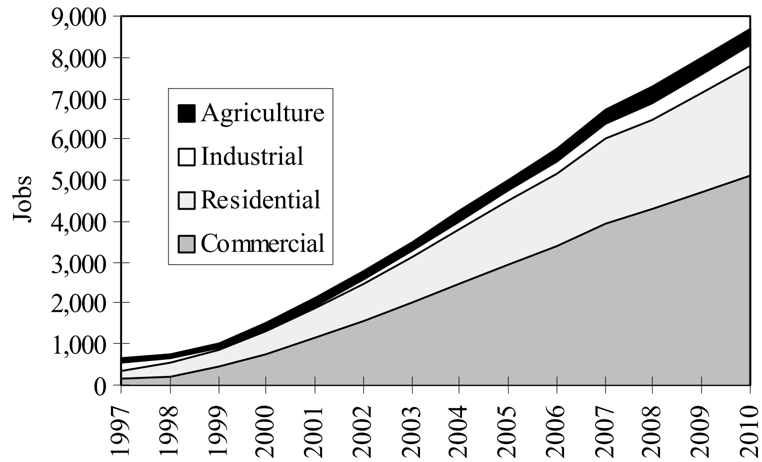

Fig. 3-2. Total employment generated from energy efficiency and fuel switching investments made in the each sector of the economy.

Industrial and agricultural investments result in less overall job growth because the overall level of investment and subsequent electricity savings included in this analysis for these two sectors are much lower than for the other sectors. Industrial investments are relatively small due to a lack of sufficient data on energy efficiency and fuel switching measures for the industrial sector. Since Wisconsin's industries consume over one-third of total electricity sold in the state, there is a much greater potential for electricity savings, emission reductions and job growth from investments in energy efficiency and fuel switching in the industrial sector than illustrated in this study.

Additional data on energy efficiency investments in the industrial sector should be collected in the future to better understand this potential. Agricultural investments are relatively small because this sector only consumes three percent of the electricity sold in the state. Consequently, the total potential for electricity and emission savings are much smaller in the agricultural sector than the other sectors.

Energy savings in the residential sector result in higher disposable income, which leads to an increase in employment through greater local consumption of goods and services other than electricity, as shown in Fig. 3-3. Energy savings in the commercial and industrial sectors lower the cost of doing business and can increase the competitiveness, productivity and profitability of Wisconsin industries. If businesses in other states do not capture the benefits of increased energy efficiency, Wisconsin industry will increase their competitive advantage. If businesses in other states also realize a similar level of

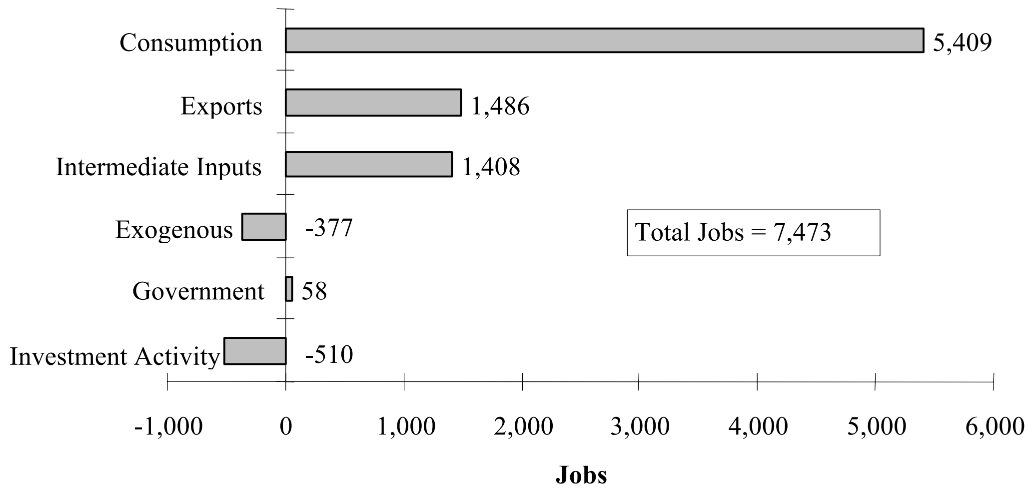

Fig. 3-3. Total additional private nonfarm employment in 2010, by source of demand (for scenario including all measures costing up to $0 per ton of CO_2 reduced). This does not include 1,052 jobs created in the government sector in 2010. This chart reflects jobs created in private industries that supply goods and services to meet the increase in economic activity in the government sector.

energy bill savings and all other factors affecting the cost of doing business remain equal, Wisconsin businesses will maintain their competitive position.

For businesses that sell primarily in regional markets, energy savings are passed on to consumers through lower selling prices of goods and services. This stimulates further consumption and demand for intermediate inputs both locally and outside the region, which creates additional jobs in Wisconsin. Furthermore, it causes exports and the percentage of goods supplied locally to increase while imports decline. For regional businesses that sell primarily in national markets, electricity savings result in increased profitability. The effects on selling prices and regional profitability of manufacturing industries are illustrated in Fig. 3-1.

Distribution of Employment

Investments in energy efficient technologies create jobs in nearly all industries in Wisconsin's economy, as shown in Fig. 3-4. The service and retail trade industries realize the greatest employment increase as consumers spend energy savings on consumption and service related activities (such as health care, lodging, amusements, restaurants, business services, auto repair, etc.) Energy saved in commercial buildings also lowers the cost of delivering services, which increases the demand for Wisconsin services and creates additional employment and income.

SECTION 3

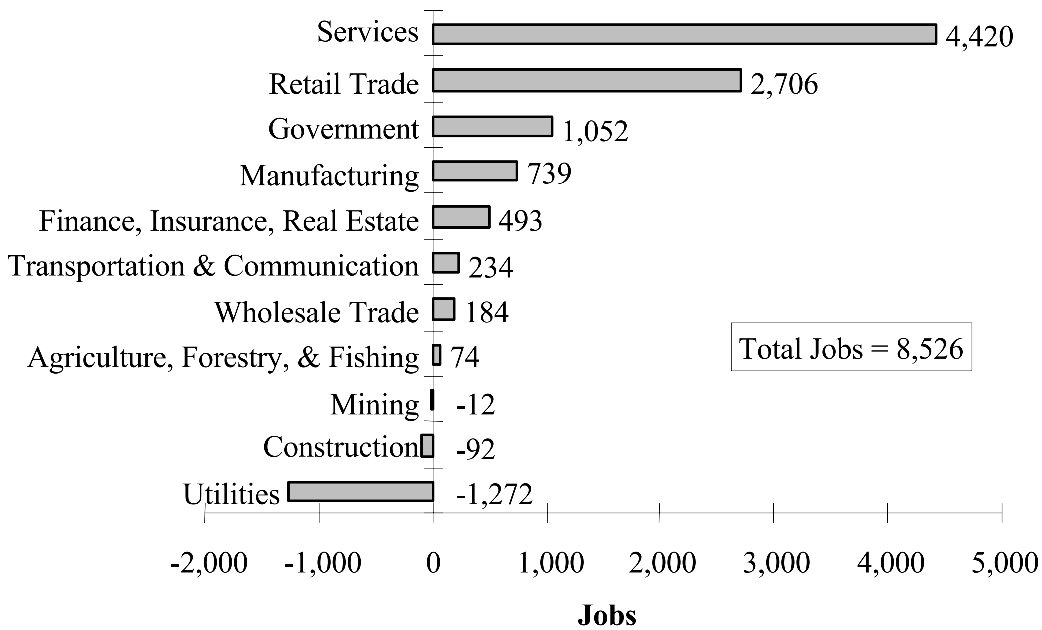

Fig. 3-4. Distribution of employment in 2010 resulting from energy efficiency and fuel switching investments (for scenario including all measures costing up to $0 per ton of CO_2 reduced).

The local sale of energy efficient appliances and technologies generates job growth in retail and wholesale trade. Increased demand for jobs and higher real disposable income per capita leads to inward migration and population growth. This increases the demand for services which results in employment growth in the government sector.

The utility sector realizes the largest decline in employment as electricity savings from consumers and businesses purchasing energy efficient technologies results in lost electricity sales compared to the baseline.

Employment in the construction sector, which includes the labor for installation and maintenance of appliances, also declines slightly because certain efficient technologies considered in this study have longer lifetimes than the standard technology they are replacing, requiring fewer replacements and lower maintenance costs. Most of this occurs through investments in energy efficient lighting (i.e. replacing incandescent bulbs with compact fluorescent bulbs).

SECTION 3

Impacts of $100 per ton of CO_2 Reduced Scenario

The installation of more expensive energy efficiency and fuel switching measures included in the up to $100 a ton case results, by 2010, would provide an 11 percent increase in energy and emission savings and a decline in economic benefits compared to installing only cost-effective measures.

Despite the reduced economic benefits, the overall economic impact on Wisconsin employment, income and GSP net of the electric sector remains positive. Table 3-2 illustrates that energy efficiency investments by Wisconsin residents, businesses and farmers costing up to $100 per ton of CO_2 reduced will create 7,255 new jobs, $428 million in higher disposable income and $266 million in GSP net of the electric sector in 2010 compared to baseline projections. Wisconsin can achieve these economic benefits while reducing Wisconsin's greenhouse gas emissions by 8.4 million tons which is 23 percent of the reductions required to reduce emissions to the 1990 level and saving 15 percent of projected statewide electricity use.

Table 3-2. Economic impacts of electric energy efficiency and fuel switching investments in Wisconsin

(for scenario including all measures costing up to $100 per ton of CO_2 reduced)

Impact	2000	2005	2010
Employment	221	3,538	7,255
Real disposable income (millions 92$)	45	235	428
Gross state product (millions 92$)	–131	–106	–42
GSP net of utility sector (millions 92$)	16	130	266

SECTION 4

CONCLUSIONS

This study shows that investing in cost-effective end use electricity energy efficiency and fuel switching measures included in the up to $0 a ton case will lower greenhouse gas emissions produced from fossil fuel combustion while delivering employment and income benefits to Wisconsin's residents, businesses and farmers. These investments produce net savings that increase disposable income for residents to spend on goods and services other than electricity. In addition, by lowering the cost of producing goods and delivering services, they increase the competitiveness, productivity and profitability of Wisconsin businesses. Furthermore, these technologies use less energy to deliver a similar and often improved level of service (heating, cooling, lighting and power), comfort and convenience.

The results show that the cost-effective scenario with investments of $1.75 billion in energy efficient technologies by Wisconsin residents, businesses and farmers would:

- Create 8,500 new jobs, $490 million in disposable income and $41 million in gross state product by 2010 (see Table 1).

- Reduce Wisconsin's greenhouse gas emissions by 7.7 million tons in 2010, which is 21 percent of the amount needed to reduce greenhouse gas emissions to their 1990 level.

- Reduce projected statewide electricity use in Wisconsin by more than 9 million megawatt hours in 2010. This is equivalent to displacing the electricity and emissions generated from five 265 megawatt power plants or consumed annually by over one million households.

- Reduce the need for electric generation capacity additions by 1300 megawatts.

- Decrease energy and operating expenditures by $4.44 billion between 1997 and 2010. Given the investment of $1.75 billion needed to install the more efficient technologies for consumers and businesses during the same period, this amounts to a total net savings of $2.69 billion or a benefit-cost ratio of 2.7.

The installation of measures included in the up to $100 a ton case considered in this study also produces increased employment, increased disposable income, and increased gross state product net of the utility industry. However, the up to $100 a ton case produced a decline in overall gross state product.

SECTION 4

Further research is needed to identify the economic impacts of additional measures to reduce greenhouse gas emissions. For example, previous research has shown that increasing renewable energy use 75 percent in Wisconsin by 2010 would create 3,316 more jobs, $81 million in higher disposable income and a $165 million increase in gross regional product than investments in fossil fuels, while moving Wisconsin 10 percent of the way to reducing greenhouse gas emissions to their 1990 levels (Clemmer, 1995).

It would be useful to identify the economic impacts of other additional measures for reducing greenhouse gas emissions, including implementation of cleaner electric generation technologies, switching existing coal fired boilers to natural gas, higher fuel efficiency of vehicles, improving the efficiency of entire processes in the industrial sector, and reducing the use of natural gas, petroleum products, and coal in homes and businesses in Wisconsin through investments in energy efficient measures.

The public policy decisions on what actions should be taken to reduce Wisconsin's greenhouse gas emissions will need to balance the full range of costs and benefits of various actions. This report was developed to contribute to the foundation for these public policy decisions.

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APPENDIX A

Summary of the Cost Screening Approach Used in the Wisconsin Greenhouse Gas Emission Reduction Cost Study (WDNR, 1998) to Select Energy Efficiency and Fuel Switching Measures at Each Cost Level

The WDNR (1998) study used a utility perspective analysis to identify the energy efficiency and fuel switching measures with the lowest net life cycle cost per ton of carbon dioxide (CO_2) reduced.This was done using the following four steps:

1. Net life cycle costs were calculated by subtracting the incremental savings over the life of an efficient measure from the incremental capital and operating costs above those of the standard replacement technology. Incremental energy savings were calculated by multiplying electricity (kilowatt-hour) and capacity (kilowatt) savings by the avoided cost of building and operating a new baseload coal power plant and transmission and distribution facilities.This avoided cost is equal to about five cents per kilowatt-hour.

2. CO_2-equivalent emission reductions were calculated for each measure by multiplying electricity savings by the average emission factor for generating electricity in Wisconsin of 1.81 pounds of CO_2 per kilowatt-hour of electricity delivered.

3. The total net costs and total emission reductions for each measure were found by multiplying the incremental costs and emission reductions determined in the cost screening by the total population of units eligible for replacement. The eligible population was adjusted to account for the existing saturation of efficient measures.

4. Total net costs were divided by total emissions reduction for each measure to derive the total net costs per ton of CO_2 reduced.

The results of this screening process are shown in Appendix B.

APPENDIX B

Appendix B
List of Specific Efficiency Measures
Ranked by Their Net Cost of Reducing Greenhouse Gas Emissions
From the Wisconsin Greenhouse Gas Emission Reduction Cost Study, (WDNR, 1998)
Which Used a Utility Cost Perspective

Sector	End Use	Market Segment	Base Technology	End Use Energy Efficiency and End Use Fuel Switching Measures	Net CO_2 savings			
					Ind. Measures (tons)	Cumulative (million tons)	Net CO_2 reduction costs ($)	Net CO_2 reduction costs ($/Ton)
Residential	Water Heating	Single Family	Electric Water Heater	Gas Water Heater	435,225	0.435	–$117,240,621	–$269
Residential	Space Heating	Single Family	Heat Pump	Gas Furnace (Condensing)	3,521	0.439	–$518,869	–$147
Commercial	Refrigeration	Grocery	Refrigeration Base Case	Doors/Covers on Cases	4,512	0.443	–$622,504	–$138
Industrial	Air Conditioning	———	Base Case (125 Ton)	Gas Chiller (125 Ton)	4,389	0.448	–$483,277	–$110
Commercial	Refrigeration	Grocery	Conventional Refrigeration	Mechanical Refrigeration	38,473	0.486	–$4,023,815	–$105
Commercial	Cooking	Office	Electric Cooking Base	Gas Cooking	9,042	0.495	–$913,716	–$101
Residential	Space Cooling	Multi-family	Central A/C	Ground Source Heat Pump	32,966	0.528	–$3,323,404	–$101
Commercial	Cooking	Warehouse	Electric Cooking Base	Gas Cooking	950	0.529	–$95,134	–$100
Commercial	Cooking	School	Electric Cooking Base	Gas Cooking	6,148	0.535	–$589,013	–$96
Commercial	Cooking	College	Electric Cooking Base	Gas Cooking	2,980	0.538	–$282,600	–$95
Residential	Space Cooling	Single Family	Central A/C	Ground Source Heat Pump	189,070	0.727	–$17,894,342	–$95
Commercial	Cooking	Grocery	Electric Cooking Base	Gas Cooking	3,130	0.730	–$294,236	–$94
Commercial	Cooking	Miscellaneous	Electric Cooking Base	Gas Cooking	6,186	0.737	–$576,089	–$93
Residential	Space Heating	Multi-family	Heat Pump	Gas Furnace (Condensing)	1,679	0.738	–$155,867	–$93
Commercial	Cooking	Restaurant	Electric Cooking Base	Gas Cooking	107,490	0.846	–$9,905,752	–$92
Commercial	Cooking	Retail	Electric Cooking Base	Gas Cooking	4,899	0.851	–$450,149	–$92
Residential	Space Cooling	Multi-family	Room A/C	Room A/C: Efficient	7,670	0.858	–$701,218	–$91
Commercial	Cooking	Health	Electric Cooking Base	Gas Cooking	11,121	0.869	–$998,479	–$90
Commercial	Cooking	Lodging	Electric Cooking Base	Gas Cooking	4,283	0.874	–$372,658	–$87
Industrial	Space Heating	———	Electric Resistance Heat	Gas Heat	22,118	0.896	–$1,796,005	–$81
Commercial	Lighting	Lodging	High Efficiency Fluorescents	HE Fluor. w/Reflectors	2,026	0.898	–$163,900	–$81
Residential	Freezing	Multi-family	Average Freezer	Efficient Freezer	13,102	0.911	–$1,055,582	–$81

APPENDIX B

Sector	End Use	Market Segment	Base Technology	End Use Energy Efficiency and End Use Fuel Switching Measures	Net CO_2 savings: Ind. Measures (tons)	Net CO_2 savings: Cumulative (million tons)	Net CO_2 reduction costs ($)	Net CO_2 reduction costs ($/Ton)
Residential	Freezing	Single Family	Average Freezer	Efficient Freezer	128,683	1.040	–$10,270,657	–$80
Commercial	Lighting	Miscellaneous	High Efficiency Fluorescents	HE Fluor. w/Reflectors	8,357	1.048	–$651,018	–$78
Commercial	Space Heating	School	Electric Heating Base	High Efficiency Gas	7,515	1.056	–$576,388	–$77
Commercial	Space Heating	Miscellaneous	Electric Heating Base	High Efficiency Gas	26,002	1.082	–$1,993,414	–$77
Commercial	Space Heating	Grocery	Electric Heating Base	High Efficiency Gas	6,591	1.088	–$505,280	–$77
Commercial	Space Heating	Health	Electric Heating Base	High Efficiency Gas	18,497	1.107	–$1,415,909	–$77
Commercial	Space Heating	Office	Electric Heating Base	High Efficiency Gas	56,693	1.163	–$4,338,563	–$77
Commercial	Space Heating	Restaurant	Electric Heating Base	High Efficiency Gas	5,488	1.169	–$419,714	–$76
Commercial	Space Heating	Retail	Electric Heating Base	High Efficiency Gas	16,203	1.185	–$1,236,793	–$76
Commercial	Space Heating	Warehouse	Electric Heating Base	High Efficiency Gas	9,359	1.194	–$713,305	–$76
Commercial	Space Heating	Lodging	Electric Heating Base	High Efficiency Gas	15,790	1.210	–$1,202,053	–$76
Commercial	Space Heating	College	Electric Heating	High Efficiency Gas	2,119	1.212	–$160,802	–$76
Commercial	Lighting	School	High Efficiency Fluorescents	HE Fluor. w/Reflectors	11,336	1.224	–$852,511	–$75
Commercial	Lighting	Health	High Efficiency Fluorescents	HE Fluor. w/Reflectors	24,442	1.248	–$1,819,613	–$74
Commercial	Lighting	College	High Efficiency Fluorescents	HE Fluor. w/Reflectors	18,043	1.266	–$1,335,531	–$74
Commercial	Lighting	Office	High Efficiency Fluorescents	HE Fluor. w/Reflectors	49,234	1.315	–$3,555,777	–$72
Commercial	Lighting	Warehouse	Incandescent Spots & Floods	Metal Halide	8,533	1.324	–$552,876	–$65
Agriculture	Other/General	———	Engine Heater w/o Timer	Engine Heater with Timer	35,219	1.359	–$2,248,073	–$64
Commercial	Lighting	Restaurant	Incandescent Spots & Floods	Metal Halide	19,087	1.378	–$1,206,890	–$63
Commercial	Lighting	Office	Standard Fluorescent Base	HE Fluor. w/Reflectors	167,144	1.545	–$10,511,421	–$63
Commercial	Lighting	Grocery	Incandescent Spots & Floods	Metal Halide	11,694	1.557	–$732,370	–$63
Industrial	Compressed Air	———	SE Motor (No First Cost)	Pneumatic Motor Replacement	36,571	1.594	–$2,289,143	–$63
Commercial	Lighting	Office	Incandescent Spots & Floods	Metal Halide	34,174	1.628	–$2,126,033	–$62
Commercial	Lighting	Miscellaneous	Standard Fluorescent Base	HE Fluor. w/Reflectors	96,783	1.725	–$5,943,848	–$61
Commercial	Lighting	Health	Standard Fluorescent Base	HE Fluor. w/Reflectors	84,068	1.809	–$5,141,047	–$61
Commercial	Lighting	Retail	Incandescent Spots & Floods	Metal Halide	70,343	1.879	–$4,283,126	–$61

APPENDIX B

Sector	End Use	Market Segment	Base Technology	End Use Energy Efficiency and End Use Fuel Switching Measures	Net CO_2 savings: Ind. Measures (tons)	Net CO_2 savings: Cumulative (million tons)	Net CO_2 reduction costs ($)	Net CO_2 reduction costs ($/Ton)
Commercial	Water Heating	Restaurant	Base Water Heat	Heat Pump Water Heater	47,238	1.926	–$2,851,469	–$60
Commercial	Lighting	School	Standard Fluorescent Base	HE Fluor. w/Reflectors	58,656	1.985	–$3,540,391	–$60
Commercial	Lighting	Miscellaneous	Incandescent Spots & Floods	Metal Halide	17,706	2.003	–$1,062,136	–$60
Industrial	Drying Fans	———	Base Case, No 1st Cost	Dryer Control System	227,644	2.230	–$13,581,969	–$60
Industrial	Hydraulics	———	200 Hp Base (No 1st Cost)	Downsize Motor to 60 Hp	674	2.231	–$40,110	–$60
Commercial	Lighting	College	Standard Fluorescent Base	HE Fluor. w/Reflectors	18,076	2.249	–$1,074,511	–$59
Residential	Water Heating	Single Family	Electric Water Heater	Heat Pump Water Heater	183,271	2.432	–$10,820,860	–$59
Commercial	Lighting	Health	Incandescent Spots & Floods	Metal Halide	7,958	2.440	–$468,428	–$59
Commercial	Lighting	School	Incandescent Spots & Floods	Metal Halide	3,109	2.443	–$182,120	–$59
Commercial	Water Heating	College	Base Water Heat	Heat Pump Water Heater	8,629	2.452	–$500,522	–$58
Commercial	Lighting	College	Incandescent Spots & Floods	Metal Halide	4,853	2.457	–$279,397	–$58
Commercial	Lighting	Lodging	Standard Fluorescent Base	HE Fluor. w/Reflectors (S)	5,903	2.463	–$338,935	–$57
Residential	Clothes Drying	Single Family	Electric Dryer (New)	Gas Dryer: 1994 min eff. strd	390,451	2.853	–$22,184,772	–$57
Industrial	Motors	———	40 Hp SE Motor Base	40 Hp HE Motor	9,356	2.862	–$526,382	–$56
Commercial	Water Heating	Lodging	Base Water Heat	Heat Pump Water Heater	11,890	2.874	–$661,186	–$56
Agriculture	Stock Watering	———	Elect. Heated Waterer	Energy-Free Waterer	1,430	2.876	–$79,149	–$55
Commercial	Air Conditioning	Grocery	Conventional Cooling Base	Desiccant Dehumidifier	13,704	2.889	–$755,709	–$55
Commercial	Water Heating	Health	Base Water Heat	Heat Pump Water Heater	15,672	2.905	–$860,995	–$55
Industrial	Refrigeration	———	Refrig. Base, no 1st cost	Control System	3,783	2.909	–$206,013	–$54
Residential	Clothes Drying	Multi-family	Electric Dryer (New)	Gas Dryer: 1994 min eff. strd	62,427	2.971	–$3,388,230	–$54
Industrial	Motors	———	75 Hp Standard Motor	75 Hp Efficient Motor	23,701	2.995	–$1,270,441	–$54
Commercial	Water Heating	Grocery	Base Water Heat	Heat Pump Water Heater	5,215	3.000	–$278,603	–$53
Commercial	Lighting	Lodging	Incandescent Spots & Floo	Metal Halide	5,526	3.006	–$294,896	–$53
Commercial	Space Heating	Restaurant	All Space Heating Base [C	Air-to-Air Heat Exchanger	2,110	3.008	–$108,687	–$52
Industrial	Space Heating	———	Base Case (no first cost)	High Efficiency Heat Pump	69	3.008	–$3,535	–$51
Commercial	Water Heating	School	Base Water Heat	Heat Pump Water Heater	10,475	3.018	–$534,907	–$51

APPENDIX B

Sector	End Use	Market Segment	Base Technology	End Use Energy Efficiency and End Use Fuel Switching Measures	Net CO_2 savings: Ind. Measures (tons)	Net CO_2 savings: Cumulative (million tons)	Net CO_2 reduction costs ($)	Net CO_2 reduction costs ($/Ton)
Industrial	Motors	———	150 Hp Standard Motor	150 Hp Efficient Motor	526	3.019	–$26,628	–$51
Industrial	Motors	———	15 Hp Standard Motor	15 Hp Efficient Motor	26,333	3.045	–$1,320,740	–$50
Commercial	Space Heating	Warehouse	All Space Heating Base	Air-to-Air Heat Exchanger	468	3.046	–$23,430	–$50
Residential	Water Heating	Multi-family	Electric Water Heater	Gas Water Heater	99,608	3.145	–$4,927,412	–$49
Agriculture	Lighting	———	250-Watt Brooder Lamp	175-Watt Infrared Heat Lmp	108,927	3.254	–$5,226,876	–$48
Industrial	Motors	———	5 Hp Standard Motor	5 Hp Efficient Motor	16,997	3.271	–$763,369	–$45
Commercial	Cooking	Restaurant	Base Cooking	Convection Ovens	3,410	3.275	–$145,670	–$43
Commercial	Water Heating	Warehouse	Base Water Heat	Heat Pump Water Heater	11,074	3.286	–$463,527	–$42
Industrial	Materials Handling		Base Case (No First Cost)	Pneumatic to Mechanical	20,226	3.306	–$844,675	–$42
Commercial	Water Heating	Office	Base Water Heat	Heat Pump Water Heater	16,223	3.322	–$673,786	–$42
Residential	Refrigeration	Single Family	Refrigerator: Primary AVG.	Adaptive Defrost - 18 ft_3	1,314,954	4.637	–$54,220,023	–$41
Commercial	Air Conditioning	Grocery	DX Base	High Efficiency DX	9,428	4.647	–$379,964	–$40
Commercial	Water Heating	Retail	Base Water Heat	Heat Pump Water Heater	20,324	4.667	–$818,342	–$40
Commercial	Lighting	Grocery	Standard Incandescent	Screw-In Fluorescent	23,932	4.691	–$919,916	–$38
Commercial	Water Heating	Miscellaneous	Base Water Heat	Heat Pump Water Heater	14,065	4.705	–$530,379	–$38
Commercial	Lighting	Retail	Standard Incandescent	Screw-In Fluorescent	65,661	4.771	–$2,462,226	–$37
Industrial	Motors	———	200Hp Standard Motor	200 Hp HE Motor	13,206	4.784	–$487,423	–$37
Commercial	Ventilation	School	All Ventilation Base	Reduce Fan Power	1,214	4.785	–$43,552	–$36
Commercial	Lighting	Health	Standard Incandescent	Screw-In Fluorescent	35,766	4.821	–$1,214,239	–$34
Residential	Clothes Drying	Single Family	Electric Dryer (New)	High Spin Washer (850 rpm)	95,067	4.916	–$3,200,984	–$34
Commercial	Air Conditioning	Warehouse	Central Chiller Base	Efficient Central Chiller	80	4.916	–$2,665	–$33
Commercial	Space Heating	College	All Space Heating Base	Air-to-Air Heat Exchanger	81	4.916	–$2,645	–$33
Commercial	Air Conditioning	Lodging	DX Base	High Efficiency DX	2,771	4.919	–$89,818	–$32
Commercial	Lighting	Office	Standard Incandescent	Screw-In Fluorescent	108,908	5.028	–$3,528,392	–$32
Agriculture	Water Heating	———	80-gal elec. water heater	High eff. 80-gal wt. htr.	908	5.029	–$28,620	–$32
Agriculture	Water Heating	———	80-gal Elec. Water Heater	Desuperheater	13,700	5.042	–$430,827	–$31

APPENDIX B

Sector	End Use	Market Segment	Base Technology	End Use Energy Efficiency and End Use Fuel Switching Measures	Net CO_2 savings: Ind. Measures (tons)	Net CO_2 savings: Cumulative (million tons)	Net CO_2 reduction costs ($)	Net CO_2 reduction costs ($/Ton)
Commercial	Lighting	Warehouse	Standard Incandescent Bas	Screw-In Fluorescent	62,450	5.105	–$1,963,002	–$31
Commercial	Lighting	Miscellaneous	Standard Incandescent Bas	Screw-In Fluorescent	117,186	5.222	–$3,518,745	–$30
Commercial	Air Conditioning	Health	DX Base	High Efficiency DX	21,855	5.244	–$654,986	–$30
Commercial	Air Conditioning	Retail	DX Base	High Efficiency DX	55,534	5.299	–$1,614,974	–$29
Industrial	Process Cooling	———	Base Case (60 HP)	Adjustable Speed Drives	15,860	5.315	–$460,589	–$29
Industrial	Lighting	———	Incandescent Lamp	Compact Fluorescents	72,725	5.388	–$2,106,302	–$29
Commercial	Lighting	Restaurant	Standard Incandescent Bas	Screw-In Fluorescent	87,622	5.476	–$2,536,696	–$29
Commercial	Lighting	School	Standard Incandescent Bas	Screw-In Fluorescent	40,957	5.517	–$1,178,372	–$29
Residential	Lighting	Single Family	40-W Fluor. w/New Ballast	34-W Fluor. w/Elec. Ballast	8,103	5.525	–$232,515	–$29
Residential	Lighting	Multi-family	40-W Fluor. w/New Ballast	34-W Fluor. w/Elec. Ballast	2,485	5.527	–$71,316	–$29
Commercial	Lighting	College	Standard Incandescent Bas	Screw-In Fluorescent	26,990	5.554	–$763,780	–$28
Commercial	Air Conditioning	Office	DX Base	High Efficiency DX	41,722	5.596	–$1,133,905	–$27
Residential	Clothes Drying	Multi-family	Electric Dryer: Typ New	High Spin Washer (850 rpm)	15,450	5.611	–$391,113	–$25
Industrial	Air Conditioning	———	Base Case (200 Ton)	High Efficiency (200 Ton)	3,518	5.615	–$80,825	–$23
Industrial	Lighting	———	4&8’ L&B, no first costs	Reflectors & Delamping	103,483	5.718	–$2,313,318	–$22
Commercial	Air Conditioning	Restaurant	All Cooling Base	Economizer	8,777	5.727	–$196,160	–$22
Commercial	Air Conditioning	Miscellaneous	All Cooling Base	Economizer	11,080	5.738	–$246,779	–$22
Commercial	Lighting	Lodging	Standard Incandescent Bas	Screw-In Fluorescent	96,588	5.835	–$2,001,158	–$21
Commercial	Air Conditioning	Warehouse	DX Base	High Efficiency DX	18,139	5.853	–$368,080	–$20
Industrial	Ventilation	———	Vent. Base, No 1st Cost	Adjustable Speed Drives	165,902	6.019	–$3,332,583	–$20
Residential	Space Heating	Multi-family	Elect. Furnace w/Std. Therm	Ground Source Heat Pump	68,444	6.087	–$1,217,830	–$18
Residential	Refrigeration	Multi-family	Refrigerator: Primary AVG.	Adaptive Defrost - 18 ft3	133,110	6.220	–$2,304,168	–$17
Industrial	Lighting	———	Metal Halide Base	High Pressure Sodium	92,960	6.313	–$1,443,789	–$16
Commercial	Air Conditioning	School	Central Chiller Base	High Eff. Central Chiller	1,947	6.315	–$27,518	–$14
Agriculture	Lighting	———	Std Incandescent Lamps	Cmpct Fluorescent Lamps	9,272	6.324	–$127,796	–$14
Industrial	Process Cooling	———	Base Case (200 HP)	Well/Ground Water w/Cond.	24,712	6.349	–$334,905	–$14

APPENDIX B

Sector	End Use	Market Segment	Base Technology	End Use Energy Efficiency and End Use Fuel Switching Measures	Net CO_2 savings: Ind. Measures (tons)	Net CO_2 savings: Cumulative (million tons)	Net CO_2 reduction costs ($)	Net CO_2 reduction costs ($/Ton)
Commercial	Refrigeration	Warehouse	Refrigeration Base Case	Mechanical Subcooling	20,049	6.369	–$270,915	–$14
Industrial	Air Conditioning	———	Base Case (125 Ton)	High Efficiency (125 Ton)	1,740	6.371	–$21,826	–$13
Commercial	Air Conditioning	Lodging	Electric Chiller Base	Gas Engine Driven Chiller	2,742	6.374	–$33,273	–$12
Residential	Lighting	Multi-family	Stnd. Incandescent Lamps	Compact Fluorescent Lamps	213,978	6.588	–$1,860,268	–$9
Residential	Lighting	Single Family	Stnd. Incandescent Lamps	Compact Fluorescent Lamps	1,008,587	7.596	–$8,768,400	–$9
Agriculture	Lighting	———	Mercury Vapor Lamps	High Pressure Sodium Lamp	235,170	7.831	–$1,921,676	–$8
Commercial	Air Conditioning	Health	Electric Chiller Base	Gas Engine Driven Chiller	12,906	7.844	–$88,327	–$7
Commercial	Air Conditioning	College	Central Chiller Base	High Eff. Central Chiller	2,915	7.847	–$16,180	–$6
Commercial	Air Conditioning	School	DX Base	High Efficiency DX	915	7.848	–$3,226	–$4
Commercial	Ventilation	Health	All Ventilation Base	Adjustable Speed Drive	27,491	7.876	$29,227	$1
Commercial	Lighting	Grocery	Mercury Vapor Base	High Pressure Sodium	1,479	7.877	$3,351	$2
Commercial	Air Conditioning	Office	Electric Chiller Base	Gas Engine Driven Chiller	23,467	7.901	$70,028	$3
Commercial	Air Conditioning	College	DX Base	High Efficiency DX	2,278	7.903	$7,779	$3
Residential	Space Heating	Single Family	Elect. Furnace w/Std. Therm	Ground Source Heat Pump	172,030	8.075	$613,433	$4
Commercial	Air Conditioning	Retail	Electric Chiller Base	Gas Engine Driven Chiller	1,772	8.077	$9,774	$6
Industrial	Air Conditioning	———	Base Case (50 Ton)	High Efficiency (50 Ton)	1,160	8.078	$15,717	$14
Commercial	Ventilation	Grocery	All Ventilation Base	Adjustable Speed Drive	7,027	8.085	$100,741	$14
Commercial	Ventilation	Restaurant	All Ventilation Base	Adjustable Speed Drive	13,444	8.098	$225,893	$17
Agriculture	Lighting	———	Std. Incandescent Lamps	Cmpct Fluorescent Fixture	26,669	8.125	$530,098	$20
Commercial	Lighting	Restaurant	Mercury Vapor Base	High Pressure Sodium	377	8.125	$10,151	$27
Commercial	Air Conditioning	Lodging	All Cooling Base	Economizer	250	8.126	$8,080	$32
Commercial	Air Conditioning	Health	All Cooling Base	Economizer	1,199	8.127	$40,047	$33
Commercial	Lighting	Retail	Mercury Vapor Base	High Pressure Sodium	1,246	8.128	$44,115	$35
Commercial	Air Conditioning	Office	All Cooling Base	Economizer	2,171	8.130	$90,230	$42
Agriculture	Process Related	———	Direct-Exp Refrigeration	Well Water Pre-Cooler	6,379	8.137	$269,407	$42
Industrial	Compressed Air	———	SE Motor (No First Cost)	Adjustable Speed Drives	50,836	8.187	$2,152,335	$42

APPENDIX B

Sector	End Use	Market Segment	Base Technology	End Use Energy Efficiency and End Use Fuel Switching Measures	Net CO_2 savings: Ind. Measures (tons)	Cumulative (million tons)	Net CO_2 reduction costs ($)	($/Ton)
Commercial	Ventilation	Office	All Ventilation Base	Adjustable Speed Drive	46,345	8.234	$2,068,351	$45
Commercial	Space Heating	Miscellaneous	All Space Heating Base	Ground Source Heat Pump	4,775	8.239	$218,398	$46
Commercial	Air Conditioning	Retail	All Cooling Base	Economizer	167	8.239	$7,666	$46
Industrial	Pumping	———	75 Hp Base, No 1st Cost	Adjustable Speed Drives	323,032	8.562	$15,182,327	$47
Commercial	Space Heating	Grocery	All Space Heating Base	Ground Source Heat Pump	2,143	8.564	$105,256	$49
Commercial	Ventilation	College	All Ventilation Base	Adjustable Speed Drive	11,415	8.575	$608,758	$53
Commercial	Space Heating	Office	All Space Heating Base	Ground Source Heat Pump	15,645	8.591	$954,056	$61
Commercial	Ventilation	Retail	All Ventilation Base	Adjustable Speed Drive	29,681	8.621	$1,815,589	$61
Commercial	Ventilation	Lodging	All Ventilation Base	Adjustable Speed Drive	7,404	8.628	$460,477	$62
Commercial	Lighting	Warehouse	Mercury Vapor Base	High Pressure Sodium	3,481	8.632	$222,797	$64
Commercial	Ventilation	Miscellaneous	All Ventilation Base	Adjustable Speed Drive	38,474	8.670	$2,814,789	$73
Industrial	Hydraulics		60 Hp Base (No 1st Cost)	Variable Volume Pump	9,739	8.680	$730,982	$75
Commercial	Space Heating	Lodging	All Space Heating Base	Ground Source Heat Pump	644	8.680	$49,853	$77
Commercial	Air Conditioning	Lodging	Room AC Base	High Efficiency Room AC	3,895	8.684	$306,038	$79
Commercial	Air Conditioning	Health	Room AC Base	High Efficiency Room AC	71	8.684	$5,736	$81
Commercial	Space Heating	School	All Space Heating Base	Ground Source Heat Pump	3,246	8.688	$279,717	$86
Residential	Water Heating	Multi-family	Electric Water Heater	Heat Pump Water Heater	42,317	8.730	$3,699,538	$87
Commercial	Space Heating	Retail	All Space Heating Base	Ground Source Heat Pump	5,999	8.736	$526,063	$88
Residential	Space Cooling	Single Family	Room A/C	Room A/C: Efficient	12,576	8.749	$1,112,615	$88
Commercial	Air Conditioning	Office	Room AC Base	High Efficiency Room AC	795	8.749	$72,761	$91
Commercial	Space Heating	Health	All Space Heating Base	Ground Source Heat Pump	4,804	8.754	$464,134	$97
Commercial	Ventilation	Warehouse	All Ventilation Base	Adjustable Speed Drive	25,635	8.780	$2,506,737	$98
Commercial	Air Conditioning	Restaurant	Room AC Base	High Efficiency Room AC	1,019	8.781	$100,954	$99
Commercial	Air Conditioning	Warehouse	Electric Chiller Base	Gas Engine Driven Chiller	397	8.781	$39,529	$99

Cumulative Total = $382,241,63 Avg = $44

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